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The centralisation and the simplification of mileage statistics

and the rational solution of the problem on the Swiss Federal Railways, (1)

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Figs. 1 to 36, pp. 651 to 655.

Introduction.

In the working of any large business, the statistical service at the present time plays a particularly important part. This service is more and more considered as being an economic compass in the working of modern undertakings, and as a financial barometer indicating the efficiency of working.

The figures build up the results obtained during any given accountancy period. They shew the daily, weekly, fortnightly, monthly, quarterly, half yearly, yearly, etc., results : they make it possible thereby to compare recent figures with those of previous periods.

A well organised statistical service is required to be *exact and quick* in dealing with the documents from which the statistics are obtained, and also in preparing the final summaries thereof.

The introduction of automatic methods should therefore be considered by the Statistical Service as a particularly fortunate innovation.

This introduction of « mechanical methods », this « automatisation » of accountancy operations when abstracting the documents known as the basic papers, necessitates many prolonged investigations into the problem as a whole, and requires the headings and rulings of the original forms to be very particularly adapted to the methods in question, which have as their objective the final abstracts.

In order that a Railway Statistical Service may be properly organised, the statistical information needed must first of

(1) Translated from the French.

all be subjected to a profound analysis in order to co-ordinate finally :

— those which include the papers used in the first analysis of the original statistics with,
— those representing the final results of the enquiry.

The proper choice of these factors and their rational use will guarantee the success of the work undertaken. It is therefore not the mechanical methods, which are used purely and simply to group together and add up the figures analysed, but the useful transformation of the contents of the whole of the documents, which are only too often a chronological collection of the subject headings adapted in turn to a particular instant.

As often happens, the mere « mechanising » of the accounts simply compromises the attainment of the desired ends : exactitude and rapidity, and does not result in the realisation of large savings in the cost of the staff employed.

The method itself is not in question. Quite the contrary, the co-ordination of the headings of the original documents (analysed) with those of the final summaries (built up), and their rational superposition shew what one ought to endeavour to obtain, and is more necessary in this connection than elsewhere.

A certain logical finesse, a sense of method, ought to reveal itself from beginning to end.

Mileage statistics on the Swiss Federal Railways.

With these ideas before them, the Swiss Federal Railways started in 1923 an investigation into a whole series of improvements to be made in the preparation of various statistics, and in particular to those relating to mileage.

The Federal Railways have concentrated the mileage statistics in one of the statistical sections of the General Secretariat, at Berne. In this way, the Traffic and Running Departments each obtain the statistical abstracts affecting them from this one office.

This centralisation of the work shews the first example of savings made by suppressing work formerly carried out by each of the two Departments mentioned.

This same centralisation made it possible to suppress the Running Department Bill — « Report on the load of the train » — which was formerly prepared by the head guard and repeated the indication given on the train journal, the original document from which the reports on train delays, number of passengers, mileage of the trains and their weight are prepared. Thanks to this centralisation and the new method, the Running Department Bill — « Report on the load » — was no longer necessary, and the work of the chief guard was in this way lightened. On the other hand, the guard's journal (fig. 1), now the only paper available as the basis for the preparation of the mileage statistics has become more elaborate.

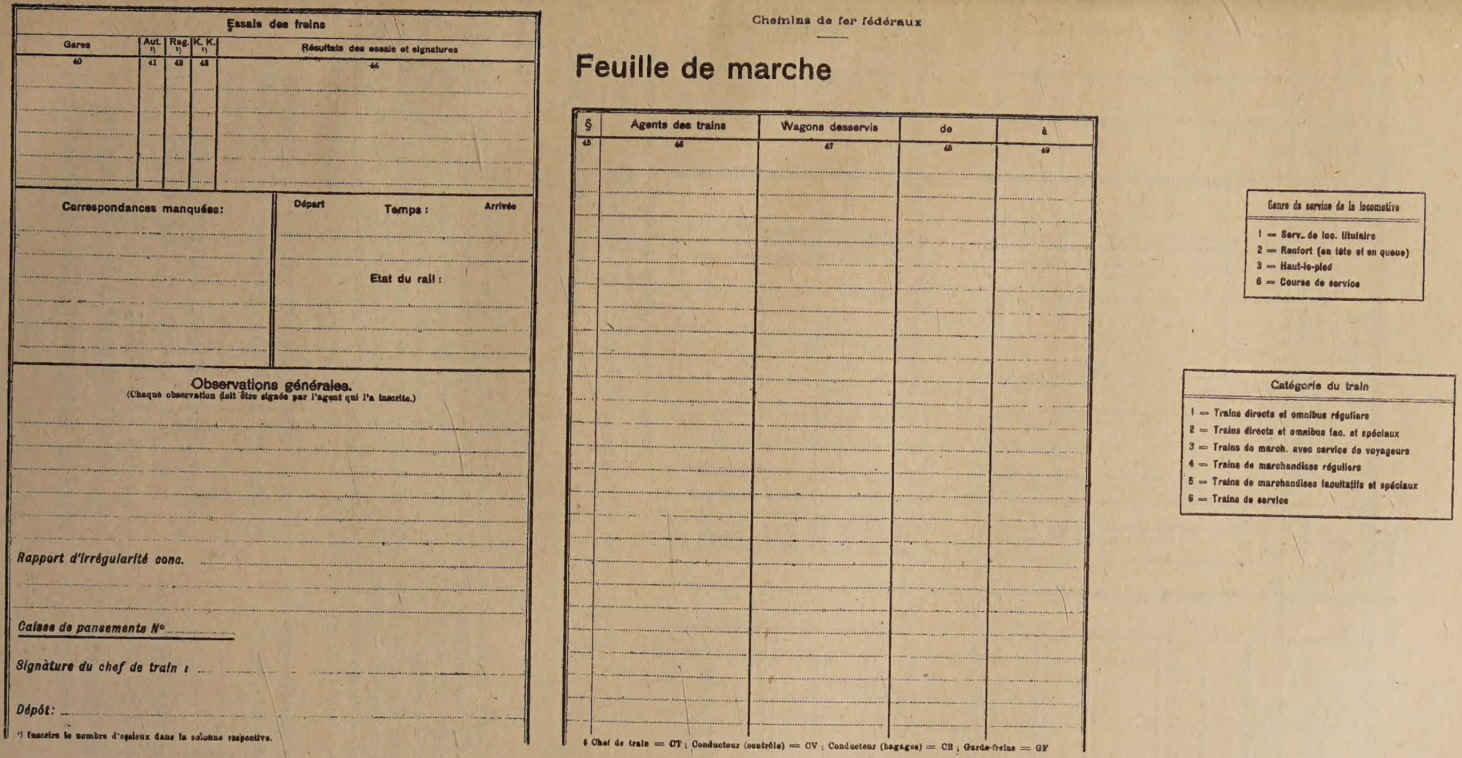
It seemed to us desirable to examine in detail the make up of the train journal, and also the way it is used.

This journal, folded in three, has on the back three separate tables with more than fifty headings to be completed by the guard.

The principal details are written in a table the full length of the front of the journal (fig. 2). They are divided into three groups :

1. the figures concerning the *Locomotive Running Department* (headings 1-7);

2. the figures concerning the *Traffic* (headings 7-21);



Essais des freins

Gares	Aut. [1]	Reg. [1]	K. K. [1]	Résultats des essais et signatures
40	41	42	43	44

Correspondances manquées:

Départ Temps: Arrivée

Etat du rail:

Observations générales.
(Chaque observation doit être signée par l'agent qui l'a inscrite.)

Rapport d'irrégularité conc.

Caisse de pansements N°

Signature du chef de train:

Dépôt:

[1] Inscrire le nombre d'essieux dans la colonne respective.

Chemins de fer fédéraux

Feuille de marche

§	Agents des trains	Wagons desservis	de	à
45	46	47	48	49

§ Chef de train = CT; Conducteur (contrôle) = CV; Conducteur (bagages) = CB; Garde-freins = GF

Genre de service de la locomotive

1 = Serv. de loc. titulaire
2 = Renfort (en tête et en queue)
3 = Haut-le-pied
6 = Course de service

Catégorie du train

1 = Trains directs et omnibus réguliers
2 = Trains directs et omnibus fac. et spéciaux
3 = Trains de march. avec service de voyageurs
4 = Trains de marchandises réguliers
5 = Trains de marchandises facultatifs et spéciaux
6 = Trains de service

Fig. 1. — Guard's journal in use on the Swiss Federal Railways (front).

Explanation of French terms :

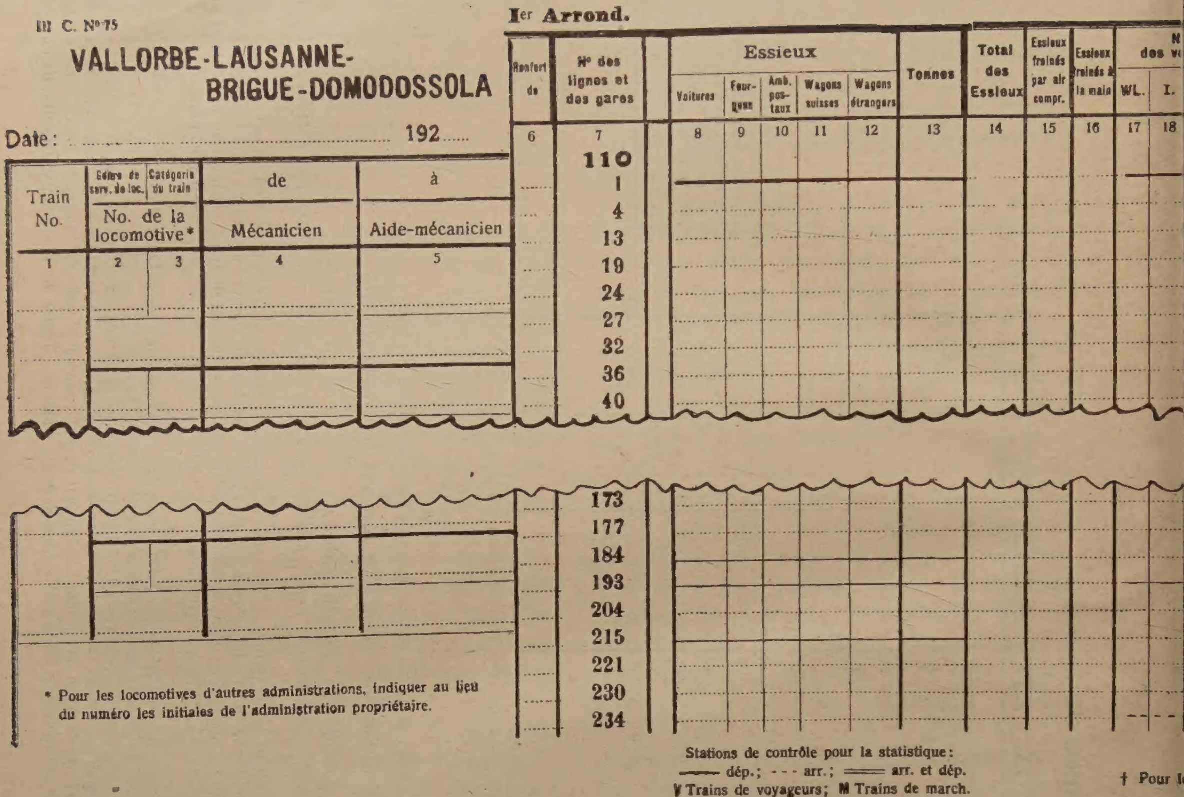
On the left : Essais des freins = Brake tests. — Gares = Stations. — Aut. = Automatic. — Reg. = Variable. — K. K. = Kunze Knorr. — Résultats des essais et signatures = Results of the tests and signatures.

Underneath : Correspondances manquées = Connections not made. — Départ = Departure. — Arrivée = Arrival. — Temps = Weather. — Etat du rail = State of the rail. — Observations générales. (Chaque observation doit être signée par l'agent qui l'a inscrite) = General notes. (Each note should be signed by the employee making it. — Rapport d'irrégularité conc. = Report of defect... — Caisse de pansements N° = Ambulance box No. — Signature du chef de train = Signature of the head guard. — Dépôt = Depot. — (1) Inscrire le nombre d'essieux dans les colonnes respectives = The number of axles is to be entered in the respective columns.

In the middle : Chemins de fer fédéraux = Swiss Federal Railways.

Underneath : Feuille de marche = Guard's journal. — Agents des trains = Train staff. — Wagons desservis = Wagons handled. — De = From. — A = To. — § Chef de train = CT ; Conducteur, etc. = § Head guard = CT ; Train conductor = C. V. ; Luggage attendant = C. B. ; Brakesman = GF.

On the right : Genre de service de la locomotive = Work done by the locomotive. — Serv. de loc. titulaire = Booked working — Renfort (en tête et en queue) = Assisting (double heading or pushing). — Haut-le-pied = Light engine. — Course de service = Service trip. — Catégorie du train = Class of train. — Trains directs et omnibus réguliers = Booked, trough and stopping trains. — Trains directs et omnibus fac. et spéciaux = Special through, stopping trains. — Train de march. avec service de voyageurs = Goods trains also conveying passengers. — Trains de marchandises réguliers = Booked goods trains. — Trains de marchandises facultatifs et spéciaux = Special goods trains. — Trains de service = Service trains.


III C. N° 75

Ier Arrond.

VALLORBE-LAUSANNE-BRIGUE-DOMODOSSOLA

Date: .... 192.....

Train No.	Génre de serv. de loc. / No. de la locomotive*	Catégorie du train	de / Mécanicien	à / Aide-mécanicien	Renfort de	N° des lignes et des gares		Essieux: Voitures	Fourgons	Amb. postaux	Wagons suisses	Wagons étrangers	Tonnes	Total des Essieux	Essieux freinés par air compr.	Essieux freinés à la main	N des v… WL.	I.
1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18
						110												
						1												
						4												
						13												
						19												
						24												
						27												
						32												
						36												
						40												
						173												
						177												
						184												
						193												
						204												
						215												
						221												
						230												
						234												

* Pour les locomotives d'autres administrations, indiquer au lieu du numéro les initiales de l'administration propriétaire.

Stations de contrôle pour la statistique:
—— dép.; - - - arr.; ═══ arr. et dép.
V Trains de voyageurs; M Trains de march.

† Pour le

Fig. 2. — Guard's journal in use

Explanation

Ier Arrond. = Ist Division. — Train N° ... du ... 192... = Train No. ... of the ... 192... — Genre de serv. de loc. = Kind of service of the locomotive. — Catégorie du train = Kind of train. — N° de la locomotive = No. of the locomotive. — De... A = From... to. — Mécanicien = Driver. — Aide-mécanicien = Fireman. — Renfort de = Assisting engine from. — N° des lignes et des gares = Number of the lines and stations. — Essieux = Axles. — Voitures = Carriages. — Fourgons = Brakes. — Amb. postaux = Post office vans. — Wagons suisses = Swiss wagons. — Wagons étrangers = Foreign wagons. — Tonnes = Metric tons. — Total des essieux = Total number of axles. — Essieux freinés par air comp. = Axles braked by compressed air. — Essieux freinés à la main = Axles handbraked. — Nombre des voyageurs † = Number of passengers †. — Gares = Stations. — Croisements. Dépassements = Trains crossed or passed. — Réguliers = Booked. — Extraordinaires = Special. — Arrivée = Arrival. — D'après l'horaire = Booked. — Réelle = Actual. — Départ = Departure. — Retard au départ

3. the figures concerning the *Operating Department* (columns 21-39).

Train journal.

1. *The figures concerning the Locomotive Running Department give :*

— the number of the train and its kind;

— the number of the locomotive and the kind of service covered;

— the sections worked over;

— the names of the driver and fireman;

— assisting and double heading.

a) The number of the trains worked

Train N° .... du .... 192...

Gares	Croisements Dépassements			Arrivée				Départ				Retard au départ	Temps perdu		Temps gagné		Motif des retards	Wagons décrochés	Signature de l'agent chargé de l'expédition du train
	régu-liers	extra-ordin.		d'après l'horaire		réelle		d'après l'horaire		réel			en gare	en marche	en gare	en marche			
21	22	23		24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Vallorbe																			
Le Day																			
Croy-Romainmôtier																			
Arnex																			
La Sarraz																			
Daillens																			
Cossonay																			
Vufflens-la-Ville																			
Bussigny																			
Gampel																			
Baron (Rarogne)																			
Visp (Viège)																			
Brig (Brigue)																			
Station du tunnel																			
Iselle																			
Varzo																			
Preglia																			
Domodossola																			

Nombre de voyageurs: ——— dép.; - - - arr.; ═══ arr. et dép.

ation ou au départ d'une station intermédiaire, noter le nombre de voyageurs à l'arrivée ou au départ.

wiss Federal Railways (back).

terms :

ime late at start. — Temps perdu = Time lost. — Temps gagné = Time made up. — En gare = In stations. — En marche = Running. — if des retards = Reason for delays. — Wagons décrochés = Wagons uncoupled. — Signature de l'agent chargé de l'expédition du 1 = Signature of employee responsible for despatching the train. — * Pour les locomotives d'autres administrations, etc. = For locoives belonging to other railways, give instead of the number the initials of the owning Company. — Stations de contrôle pour la statise: etc. = Control stations for statistics: ——— dep.; - - - arr.; ═══ arr. and dep. **V** = Passenger trains; **M** = Goods trains. — Nombre oyageurs: etc. = Number of passengers: ——— dep.; - - - arr.; ═══ arr. and dep. — † Pour les trains à destination, etc. = For is at destination or leaving an intermediate station, give the number of passengers on arrival or on leaving.

corresponds with that fixed by the time-tables. The kind is indicated by Arabic figures as follows :

1 = *Booked through and stopping trains* (including period trains);

2 = *Special booked and stopping trains* (including trains temporarily booked as regular workings by order of General Headquarters or Divisional Headquarters);

3 = *Goods trains conveying passengers* (if shewn as such in the working time-tables and by dotted line on the train diagram);

4 = *Booked goods trains* (including period trains and those which

Schweizerische Bundesbahnen
Chemins de fer fédéraux

Ier ARRONDISSEMENT.

Betriebene Bahnlänge - *Longueur exploitée*

zweispurig — *à double voie* .... km.
einspurig — *à simple voie* ....
Total 1033 km

Zugsbewegung — *Mouvement des trains*

im Monat
pendant le mois de JANVIER 19 28

Zur Ausführung gelangten — *Ont été exécutés:*

III. A. No. 44

	Zugskilometer *Kilom. d. trains*	Wagenachsenkilometr. *Kilom. essieux*
a. Im Fahrplan vorgesehene regelmässige Züge: ***Trains prévus à l'horaire comme réguliers:***		
1. 11272 Personenzüge (Schnell- und gewöhnliche Personenzüge, Personenzüge mit Güterbeförderung) mit zusammen. *Trains de voyageurs (express, omnibus et trains de voyageurs avec service de marchandises), ensemble*		
2. 202 Güterzüge mit Personenbeförderung, mit zusammen. *Trains de marchandises avec service de voyageurs, ensemble*		
3. 4416 Güterzüge ohne Personenbeförderung, mit zusammen. *Trains de marchandises sans service de voyageurs, ensemble*		
b. Fakultativ- und Extrazüge: ***Trains facultatifs et spéciaux:***		
1. 96 Personenzüge (Schnell- und gewöhnliche Personenzüge, Personenzüge mit Güterbeförderung) mit zusammen. *Trains de voyageurs (express, omnibus et trains de voyageurs avec service de marchandises), ensemble*		
2. 174 Güterzüge ohne Personenbeförderung, mit zusammen *Trains de marchandises sans service de voyageurs, ensemble*		
3. 1066 Dienst- und Hülfszüge, mit zusammen. *Trains de service, ensemble*		
Total		

LAUSANNE den/*le* 6 FEVRIER 19 28.

Unterschrift — *Signature*:

Ces deux rubriques sont remplies par la Section de Statistique à la Direction Générale à Berne.

Fig. 3. — Monthly summary of train mileages made up by the Divisional Headquarters of the Swiss Federal Railways.

Explanation of French terms: Longueur exploitée = Length operated. — A double voie... km. = Double track ... km. — A simple voie ... km. = Single track ... km. — Ier Arrondissement = Ist Division. — Mouvement des trains = Train mileage. — Pendant le mois, etc. = During the month of January 1928. — Ont été exécutés: = The following mileage has been run. — *a.* Trains prévus à l'horaire, etc. = Trains shewn in the time tables as regular workings.— Trains de voyageurs (express, etc.) = Passenger (express, stopping and passenger trains conveying goods wagons). — Trains de marchandises avec service, etc. = Goods trains conveying passengers, total. — Trains de marchandises sans service, etc. = Goods trains not conveying passengers, total. — *b.* Trains facultatifs et spéciaux = *b.* Special trains. — Trains de service, ensemble = Service, total. — Kilom. de trains = Train-kilometres (train-miles). — Kilom. essieux = Axle-kilometres (axle-miles). — Signature = Signed. — Ces deux rubriques sont remplies, etc. = These two headings are filled in by the Statistical Section at General Headquarters at Berne. — Total = Grand total.

convey one carriage over certain sections (P goods trains);

5 = *Special goods trains* (including trains temporarily booked as regular workings by order of General Headquarters and Divisional Headquarters);

6 = *Service trains* (including stock

Train number	Kind of work done by the locomotive.	Class of train.	From	To
	Locomotive number		Driver	Fireman
1	2	3	4	5
5244	1	4	Olten	Burgdorf
	799		Kleeb	Strub
2246	1	1	Burgdorf	Bern
	799		Kleeb	Strub
	or			
652	1	3	Erstfeld	Airolo
	14268		Stamm	Zumbühl
652	1	4	Airolo	Bellinzona
	14268		Stamm	Zumbühl

Fig. 4. — Extract from the guard's journal, concerning the Locomotive Department

and permanent way trains, trips with snowploughs, breakdown trains, trial runs and test trips, and trains both booked and special of empty stock).

It is to be noted that *special mixed traffic trains* (such as military trains) are considered as being :

— *special passenger trains* when the load is principally made up of *carriages;*

— *special goods trains* when they are chiefly made up of *wagons.*

When the train number or its class is altered en route, the guard records the alteration by again entering up the corresponding columns (1-5) : the same thing is done if the engine or the staff is changed.

b) The number of the locomotive or the motor coach is entered without any indication of its class.

Locomotives belonging to other railways are not as a rule recorded by number : in this case the mark of the railway owning it alone is noted.

The service worked by the locomotives is shewn by Arabic figures, in a similar way to the indications of the class of train.

The following are included under :

1 = work by *booked engine :*

— an assisting locomotive or motor coach when working at the head of the train or, in the case of suburban block trains, at the centre or back of the train whilst working the train;

Wagenrapport für Zug N° 4207 von Renens nach Berne
Rapport sur le matériel du train » de » à »

» » »

Blatt N° 1
Feuille

vom 1 – XII 1927 via Lausanne
du

N° 3504

Zugführer *Chef de train*	von *de*	nach *à*	Locomotive Serie	Locomotive N°	Locomotive Achsen *Essieux*	von *de*	nach *à*
Boss	Renens	Romont	A 3/6	10653	6	Renens	Fribourg
Ryff Ed.	Romont	Fribourg					
Bapst A.	Fribourg	Berne	A 3/6	10626	6	Fribourg	Berne

Wagen – *Véhicules* Eigentümerin *Initiales*	Serie	Personen-Gepäck u. Post *Voitures, fourgons*	Güter – *Wagons* Schweizerische Bahnen *Chemins de fer suisses*	Güter – *Wagons* Ausländische Bahnen *Chemins de fer étrangers*	Bremse *Frein*	Achsen *Essieux*	Tara *Tare*	Gewicht *Poids total*	Grenzstation *Gare frontière*	Versandstation *Gare expéditrice*	Bestimmungsstation *Gare destinataire*	Angehängt in *pris à*	Abgehängt in *laissé à*
1	2	3	4	5	6	7	8	9	10	11	12	13	14
CFF.	K		33494		1	2	9	19		Yverdon	Chexbres	Renens	Puidoux
"	"		43383		1	2	11	14		Cossonay	"	"	"
"	"		44879		1	2	11	14		"	"	"	"
"	"		28482			2	7	9		Lausanne	Puidoux	"	"
BLS.	"		3315		1	2		9		Clarens	Palezieux	"	Palezieux
CFF.	L		48615			2	5	15		Eclépens	"	"	"
"	F	16887				2	10	12		Renens	Berne	"	Berne
"	C	7148				3	20	28		"	"	"	"
"	K		37236		1	2	9	12		Genève	Fribourg	Palezieux	Fribourg
"	"		31720		1	2	9	12		Renens	"	"	"
"	"		31927		1	2	9	12		Lausanne	Berne	"	Berne
"	"		43542		1	2	11	14		Renens	"	"	Romont
"	M		59771			2	7	10		"	"	"	Berne
					1	2	11	14		"	Fribourg	"	

		Brigue	Vallorbe
99026		Wagon de chauffage	

Fig. 5. — Report on the rolling stock in use on the Swiss Federal Railways.

Explanation of French terms : Rapport sur le matériel du train N° 4207 de Renens à Berne du 1-XII 1927 via Lausanne = Report on the rolling stock forming the train No. 4207 from Renens to Berne of the 1st December 1927 via Lausanne. — Feuille N° 1 = Sheet No. 1. — Chef de train = Guard. — De ... à... = From ... to ... — Série = Class. — Essieux = Axles. — Véhicules = Vehicles. — Initiales = Initials. — Serie = Class. — Voitures, fourgons = Carriages, wagons, P. O. vans. — Chemins de fer suisses = Swiss wagons. — Chemins de fer étrangers = Foreign wagons. — Frein = Brake. — Essieux = Axles. — Tare = Tare. — Poids total = Total weight. — Gare frontière = Frontier station. — Gare expéditrice = Despatching station. — Gare destinataire = Destination station. — Pris à = Attached at. — Laissé à = Left at. — Wagon de chauffage = Heating wagon.

2 = *assisting* or *double heading service :*

— the mileages of all the other locomotives or motor coaches assisting in the haulage of trains or ready to help;

3 = mileage of *light engines :*

— the mileages of the locomotives and motor coaches running light according to booked or special workings, even when empty carriages and wagons are worked.

It should be remarked that guard's journals are not prepared for trips made by light engines when these are less than 10 km. (6.2 miles).

6 = *service mileage :*

— the working of engines on stock and work trains, breakdown trains, empty stock, booked or special, snow plough working, test or trial runs.

In case of difficulty on the electrified lines of the Federal Railways when the electric trains are worked by steam locomotives, the trips of these latter over the sections in trouble are dealt with as *shunting* service, and consequently are not recorded on the guard's journals.

Column 6 of the guard's journal covering *assistance* or *double heading* is completed by inserting the figure « 2 » in line with the station where the service *started* and where it *ended*, as well as by drawing a *vertical line* between the two stations in question to shew two engines in use, and by *two vertical lines* when there are *three machines*.

* * *

2. *The figures concerning* the *train* statistics include :

— the axles on the train;
— the load taken;
— the number of passengers.

a) The headings for the axles include :

— *vehicles* belonging to the Federal Railways and to the other Companies, motor coaches and vehicles with driver's and passenger compartments, and composite brake vehicles with luggage or Post Office compartments;
— *brake vans* of the Federal Railways and of other Railways and motor coaches with luggage compartment;
— Swiss *travelling* Post Office vans;
— Swiss goods wagons, service wagons (lighting, dynamometers, etc.) excepting heating wagons which are inserted in columns (2-5) concerning the Locomotive Running Department;
— *foreign goods wagons*, as well as foreign brake vans used for express goods and all the locomotives and motor coaches out of service conveyed by train.

In addition, special columns have been provided for the *total number of axles* of the train, as well as for the *number braked by air-brake or by hand.*

b) As *load hauled*, the total number of gross tons, including the weight of the locomotive and tender and motor coaches out of service. *The weight of motor coaches used to assist the train is not included in the weight of the train.*

c) The *number of passengers* is count-

ed by the train conductors in order to determine the distribution of passengers amongst the different classes over the different sections.

Every alteration in the number of axles and in the load of the train is carefully recorded on the line through the place where the change occurred. The statistical offices in the division summarise these figures for specially indicated stations, known as control stations.

As regards passenger statistics, the head guard notes their number on the lines provided therefore, that is :

on a heavy line. . .	━━━	the number of passengers when leaving the station.
on a double line . .	═══	the number of passengers on arrival at the station,
under a double line.		the number of passengers when leaving the station
on a dotted line. . .	– – – –	the number of passengers on arrival at the station.

For trains running without stop from the departure to the arrival station, the head guard only records the number of passengers, the number of axles and the load of the train (columns 8-20) on departure, and shews by means of an oblique line — from the top downwards — that the train in question is a through train.

The statistics of seats occupied are compiled daily at the divisional statistical offices. The monthly summaries are sent from the division to the General Headquarters at Berne, which in turn communicates them to the Federal Railway Department.

3. *The information affecting the operating department deals with :*

- — crossing and passing trains en route;
- — times of arrival and departure of the trains;
- — delays to trains, the reasons and the time made up;
- — train movements in stations;
- — signatures for control purposes of under-stationmasters or their representatives.

These particulars, in view of their importance as regards the supervision, regular running of the trains, and the due observation of the conditions laid down in the Regulations for trains in movement, ought to be carefully inserted :

— *before starting :*

— by the *office at the departure station,* especially :

— the times of departure and arrival given in the working time-tables;

— crossings and passings booked.

— *during the journey :*

— by the *guard,* especially :

— crossings and passings actually taking place, irregular and unusual;

— actual arrival and departure times (1);

---

(1) Except in cases where the Regulation for train working orders this note to be written in by the assistant stationmasters or their representatives, that is :

— at the terminus stations where the train is formed or terminates,

— at the stations, known as control stations which are designated by the Operating Department,

— at the terminal stations of a double track line temporarily worked as a single line.

— time late on leaving each station;
— time lost at stations and on the road;
— time made up at stations and on the road;
— number of wagons detached at stations during the trip.

The causes of delays should be stated briefly (figs. 6-7). They are written in by the guard and shew separately minutes lost through various stops, as for example, the late arrival of a connection, picking up wagons, increase in time taken to load luggage, post-bags, etc.

Names of the lines and stations.

The characteristics of the horizontal axis of the principal table on the guard's journal has been described above.

The particular feature of this document is the very successful introduction of a vertical axis (columns 7 and 21) fixed beforehand with the object of constantly bringing together the corresponding figures of the two ordinates.

The guard usually writes down the yards and stations on the guard's journal one below the other, as he passes them on the journey.

So as to make the journal suitable for automatically analysing it, the Management of the Federal Railways has given up the ordinary use of these journals. For each line of the system, and even for each section, a standard journal has been introduced and shews, not only the yards and stations in their proper order, but fixes beforehand the mileage, as well as the number of the line or lines if it is a question of a journey over several sections of different lines.

For this purpose, the whole of the Swiss Federal Railways has been divided into 124 lines.

In order to distinguish these lines in the three divisions of the system, Lausanne, Lucerne and Zurich, the lines are given three figure numbers, *i. e.:*

— the lines of the first Division commence with *100;*
— the lines of the second Division commence with *200;*
— the lines of the third Division commence with *300.*

It should be added also that the numbers given to the lines for the reverse direction commence

— with *600* to indicate the first Division;
— with *700* to indicate the second Division;
— with *800* to indicate the third Division.

If therefore a train from Vallorbe to Domodossola runs over line 110, this train when coming from Domodossola to Vallorbe runs over line 610, and in the same way, the line 100 La Plaine-Geneva-Cornavin refers to traffic from the Paris, Lyons and Mediterranean to the Federal Railways, whilst the line 600 shews traffic from the Federal lines to the Paris, Lyons and Mediterranean system.

The following table shews the distribution of the lines of the Federal Railways system between the Lausanne, Lucerne and Zurich divisions, as well as their decimal subdivision which also shews the geographic position of the line on the system.

This symmetrical division helps in a very flexible manner the classifying of the guard's journals in the statistical offices of the Division concerned, as well as in the Statistical section at General Head-

Schweizerische Bundesbahnen — *Chemins de fer fédéraux* — Strade ferrate federali

Beilage — *Annexe* — Allegato

zum Stundenpass des Zuges
à la feuille de marche du train № .... vom / *du* / del .... 192 .
alla cedola oraria del treno

Nº 3709

§	**Personal** *Personnel* — Personale	***Lokomotive oder bediente Wagen** *ou wagons desservis* o veicoli serviti	**von** *de* — da	**bis** *à* — a
......	....	....	....	....
......	....	....	....	....

Allgemeine Bemerkungen — *Observations générales* — Osservazioni generali

(Jede Bemerkung ist vom Eintragenden zu unterzeichnen, unter Beifügung des Stationierungsortes)
(Chaque observation doit être signée par l'agent qui l'a inscrite, avec indication du lieu de stationnement)
(Le osservazioni sono da firmarsi dall'inscrivente indicando la stazione di deposito)

Jede Unregelmässigkeit ist auf einer besondern Beilage zu melden
Chaque irrégularité doit être signalée sur une annexe spéciale
Ogni irregolarità va notificata su di uno speciale allegato

....

....

§ Lokomotivführer = L Führergehülfe = Fg Heizwagenheizer = Hh Zugführer = Z Kondukteur = K Gepäcker = G Bremser = B

Mécanicien = M aide-mécanicien = AM chauff. de wag. de chauff. = CC chef de train = CT conduct (contr.) = C conduct. (bag.) = CB garde-freins = GF

Machinista = M Ajutante macch. = AM Fochista di veicoli di riscaldamenti = FR Capotreno = CT Conduttore = C Bagagliero = B Frenatore = Fr

*Zugslokomotive = Z Vorspann = V Schiebelokomotive = S

Locomotive titulaire = T double traction = D locomotive de refoulement = R

Locomotiva del treno = L Locomotiva di rinforzo = R Locomotiva di spinta = S

Fig. 6. — Appendix to the guard's journal.

Explanation of French terms. Top : Annexe à la feuille de marche, etc. = Appendix to the guard's journal of train No. ... of the... 192... — Personnel = Staff. — * Locomotive ou wagons desservis = * Locomotive or wagons handled. — *Middle* : Observations générales = General notes. — (Chaque observation, etc.) = (Each note is to be signed by the employee making it together with the name of the stop). — Chaque irrégularité, etc. = Any irregularity in the working is to be reported separately. — *Bottom* : Mécanicien = M = Driver. — Aide-mécanicien = AM = Fireman. — Chauff. de wag. de chauff. = CC = Fireman of heating wagons. — Chef de train = CT = Guard. — Conduct. (contr.) = C = Conductor. — Conduct. (bag.) = CB = Luggage attendant. — Garde frein = GF = Brakesman. — Locomotive titulaire = T = Train engine. — Double traction = D = Double heading. = Locomotive de refoulement = R = Assisting engine.

Schweizerische Bundesbahnen
Chemins de fer fédéraux
Strade ferrate federali

LAUSANNE den .... 19 ..

Auszug aus dem Stundenpass des Zuges
Extrait de la feuille de marche du train №
Estratto della cedola oraria del treno

№

vom 19
du-del

III. A. Nr 61

Zugspersonal *Personnel des trains* Personale del treno	Lokomotivpersonal *Personnel des locomotives* Personale delle locomotive	Lokomotiven *Locomotives* Locomotive	Zugsbelastung *Charge du train* Carico del treno

Fig. 7. — Extract from guard's journal.

Explanation of French terms : Extrait de la feuille, etc. = Extract from guard's journal of train No. — Personnel des trains = Train staff. — Personnel des locomotives = Locomotive staff. — Charge du train = Load of train.

quarters and enables the work of abstracting them to be done methodically.

Statistics of traffic currents are thus considerably facilitated.

As regards the numbering of yards and stations, it was considered of value to retain the kilometric indication of each.

Thus on the Simplon line which, from an accounts point of view, is a perfect example of « *statistical homogeneity* », all the stations from Vallorbe to Domodossola, a distance of 234 kilometres, were included.

The following tables shew the make up of vertical axes of various guard's journals dealing with the whole journey from Vallorbe (C. F. F.) to Domodossola (F. S.) (fig. 9), and also to the part trips from Vallorbe to Lausanne (fig. 10), from Lausanne to Saint Maurice (fig. 11), from Saint Maurice via Sion to Brigue (fig. 12), from Sion to Brigue (fig. 13) and from Brigue to Domodossola.

The reproductions given below shew that each yard or station retains not only its kilometric index on the whole journey or on the part journey, but also that this index remains fixed for journeys in the reverse direction, that is to say, that the yards and stations of the line 110 and of line 610 retain their respective kilometric indices.

This index has in fact the character of an arithmetical photograph of any given

Fig. 8. — Map of the Swiss Federal System.

Explanation of French terms : Horaire-affiche = Time sheet. — Numérotation des lignes = Numbering of the lines. — Arrond. = Division. — Feuille = Sheet. Lignes des C. F. F. = Swiss Federal Railway lines. — Autres lignes = Other lines. — *In the right bottom corner* : Erklärung = Explanation. — Lignes internationales de transit = Lines used for international traffic. — Autres lignes = Other lines. — Lignes ne figurant pas dans l'horaire-affiche = Lines not shewn on the time sheets.

station on a line, and remains the same for stations without junctions. Junction stations can have several indices each referring to another line.

Thus Lausanne station has several indices as follows :

61 — on the line 101 Geneva-Lausanne;
6 — on the line 102 Renens-Berne;
1 — on the line 103 Lausanne-Bienne;
47 — on the line 110 Vallorbe-Domodossola;
6 — on the line 130 Renens-Lyss.

It is of course understood that on the lines 601, 602, 603, 610 and 630, Lausanne station always retains its respective kilometric indices. What differs in the case of the different lines is only the order of succession of the kilometric figures.

This order increases on the lines 100..., 200..., 300..., and decreases on the same lines considered in the opposite direction : 600..., 700..., 800...

The tables given below shew, moreover in part this detail. In fact, it will be seen from the journals Brigue-Domodossola-Brigue; Lausanne-Vallorbe- Lausanne; Brigue-Sion-Brigue, for movements of shuttle trains, that the station indices remain the same, following one another in the increasing (line 110) or decreasing (line 610) order only.

It is of interest to note that the use — in duplicate or quadruplicate — of *double journey* journals for short shuttle service journeys has certain advantages and shews some saving. The Swiss Federal Railways hare provided quite a number of such services for local or suburban service in the neighbourhood of large stations.

On the other hand, combined journals covering several lines over which, as a whole, through trains work, have been got out.

Thus the main cross-country line Delle-Berne-Loetschberg-Simplon, belonging to the Swiss Federal Railways and to the Berne - Loetschberg - Simplon Company, comprises on the Federal Railways section, from Delle to Thoune, the *group of lines :*

123 : Delle-Delemont-Bienne;
124 : Bienne-Berne;
125 : Berne-Thoune.

The guard's journal in question (fig. 14) consequently gives three successive series of kilometric indices, and is an example of a rational adaptation of the original documents to meet the needs of the statistical analysis by sections of the lines.

The total of the maximum figures for the different lines gives the mileage run over the whole journey. On the other hand, the kilometric distances between the stations are obtained by subtracting the small kilometric index from the greater. The distance from Lausanne to Brigue is then : (234-42) = 192 km.: from Brigue to Sion (193-139) = 54 km.

Statistical work.

The guard's journals got out in this way ought to be written in clearly, as required by articles 32 of the Regulations governing the movement of trains [1] so

(1) Article 32 of the Regulation of the Federal Railways is as follows :

ARTICLE 32.

Written Statements concerning trains.

Guard's Journal.

A guard's journal is to be completed for each train (fig. 1).

In the case of trains working in more than one division, a separate journal has to be completed for each division.

If within a division the train crew be chang-

Table of the decimal distribution
of the lines of the . wiss Federal Railway System

Number of the line *Outwards.*	ROUTE.	Number of the line *Return.*
100	La Plaine — Geneva	600
101	Geneva — Lausanne	601
102	Renens — Lausanne — Fribourg — Berne	602
103	Lausanne — Neuchâtel — Bienne	603
104	Nyon — Divonne	604
110	Vallorbe — Lausanne — Saint-Maurice — Domodossola	610
111	(Brassus) — Le Pont — Vallorbe	611
112	Puidoux-Chexbres — Vevey	612
113	(Saint-Gingolph) — Bouveret — Saint-Maurice	613
120	Delémont — Sonceboz	620
121	La Chaux-de-Fonds — Sonceboz — Bienne	621
122	Basel — Delémont	622
123	Delle — Delémont — Bienne	623
124	Bienne — Berne	624
125	Berne — Thoune	625
130	Lausanne — Payerne — Lyss	630
131	Yverdon — Payerne — Fribourg	631
132	Bulle — Romont	632
133	Neuchâtel — Les Verrières — Pontarlier	633
134	Le Locle-Col-des-Roches — La Chaux-de Fonds — Neuchâtel	634
201	Basel SBB — Basel BB — Kleinhüningen	701
202	Basel — Gelterkinden — Olten	702
203	Olten — Lucerne	703
204	Lucerne — Arth-Goldau — Bellinzona — Chiasso	704
210	Zürich — Thalwil — Zug — Arth-Goldau	710
211	Zürich — Affoltern a/A. — Zug	711
212	Zürich — Thalwil — Zug — Lucerne	712
213	Bellinzona — Luino	713
214	Bellinzona — Locarno	714
220	Bern — Olten	720
221	Olten — Zürich	721
222	Lyss — Solothurn HB. — Herzogenbuchsee	722
223	Biel — Olten	723
230	Zofingen — Suhr — Aarau	730
231	Aarau — Suhr — Lenzburg — Wettingen	731

Table of the decimal distribution of the lines of the Swiss Federal System *(continued)*.

Number of the line *Outwards.*	ROUTE.	Number of the line *Return.*
232	Brugg — Wohlen	732
233	Basel — Laüfelfingen — Olten	733
234	Olten — Aarau — Wohlen — Rothkreuz — Arth-Goldau	734
235	Luzern — Beinwil — via Lenzburg SBB & Lenzburg Stadt to Wildegg	735
236	Münster — Beinwil	736
240	Bern — Langnau — Luzern	740
241	Luzern — Meiringen — Interlaken Ost	741
300	Basel — Stein S. — Brugg — Zürich	800
301	Zürich — Wädenswil — Ziegelbrücke — Sargans — Chur	801
302	Zürich — Meilen — Rapperswil — Ziegelbrücke — Linthal	802
303	(Weesen — Glarus)	803
310	Zürich — Wallisellen — Winterthur	810
311	Winterthur — Wil — St. Gallen	811
312	St. Gallen — Rorschach	812
313	Rorschach — Buchs — Sargans — Chur	813
314	Zürich HB. — Wallisellen — Uster — Rapperswil	814
315	Winterthur — Bauma — Rapperswil	815
320	Niederweningen — Oberglatt	820
321	Schaffhausen — Bülach — Zürich	821
322	Waldshut — Turgi	822
323	Basel — Stein S. — Koblenz — Bülach — Winterthur	823
324	Basel — Otelfingen — Oerlikon — Zürich	824
325	Wettingen — Otelfingen — Bülach	825
330	Winterthur — Romanshorn	830
331	Sulgen — Gossau — St. Gallen	831
332	Schaffhausen — Etzwilen — Emmishofen-Kreuzl. — Kreuzlingen	832
333	Emmishofen-Kreuzl. — Konstanz — Kreuzlingen	833
334	Emmishofen-Kreuzl. — Romanshorn — Rorschach	834
340	Effretikon — Hinwil	840
341	Zürich — Kloten — Winterthur	841
342	Winterthur — Schaffhausen	842
343	Winterthur — Etzwilen — Singen	843
344	Rapperswil — Uznach — Wattwil (St. Gallen — Muolen — R'horn)	844
345	(Neslau) — Ebnat-Kappel — Wil	845

as to facilitate their analysis later on. They should therefore be filled in exactly in accordance with the form and text as printed : any alteration thereto is definitely forbidden.

The journals must be handed in the same day by the guards at the terminal stations or at the stations specified.

The stations have to see that the journals are properly filled in, and then to sort them by train number : the journals should then be sent without delay to the Divisional Headquarters by the stations. The Divisional Statistical Offices of Lausanne, Lucerne and Zurich abstract *day by day* and *train by train* the figures relative to the statistics of the *number of passengers travelling in the different classes of carriage* (fig. 15) and to the checking of the *actual weight of the train* (fig. 17) against the maximum weight allowed. They also check the regularity of the train working and abstract the *delays* occurring (fig. 18).

When this is done, the divisions forward the journals to the Statistical Section of the Federal Railways Headquarters at Berne, where they are finally abstracted. The figures the journals contain are transferred by automatic machines to a special card.

This card (fig. 19) measures 187.5 × 82.5 millimetres (7 3/8 × 3 1/4 inches) and has 45 columns of figures in vertical lines arranged in groups.

The whole of the indications have to be given in figures henceforth. Two columns enable 92 different combinations to be obtained.

If the pattern card of a trip shewn in

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ed, the continuation of the journal got out by the guard going off duty is to be covered by the new guard, so far as the journal allows, and provided the train continues its journey under the same number.

The journal must be got out by the guard in accordance with the instruction on the form.

In addition, anything unusual occurring should be inserted on the journal.

These reports should be prepared in accordance with form III. C. No. 215 (appendix to the guard's journal) (fig. 6) and be noted on the journal.

. . . .

The results of the test of the brake (fig. 1) should be noted on the journal by the station-master or the guard in accordance with the regulation on the compressed air brake.

The departure time is to be entered immediately before leaving.

In stations, where usually the station-master does not sign the journal, he should give a receipt to the guard for wagons detached from the rear of the train and left on the main line.

The reason of all delays should be given. In stations where the actual arrival and departure times are recorded by the station-master, the latter is responsible for recording the reasons for the delays. In other stations, the guard inserts the reasons for these delays.

The guard should record on the journal each stop at a signal, even if no delay result. In stations where the train has to stop, the guard must ascertain the reason for stopping at the signal and enter it on the journal

He must also enter on the journal separately how many minutes have been lost through the late arrival of a connecting train, through attaching wagons, for postal reasons, etc.

Alterations to the times and notes can only be made subsequently by the employee originally recording them. In such case the original should be crossed through, but so as to remain legible, and the new written alongside or above it.

When the guard is changed at an intermediate station, the journal with attached forms should be handed to the new guard. The latter must sign for them on the journal under the heading « Appendices » of the forms for special stops and of the forms for signal indications, crossings and crossing alterations still to be carried out; he thereby becomes responsible for their proper execution.

Lausanne-Brigue-Domodossola

1er Arrond.

Renfort de	Nº des lignes et des gares	Gares
6	7	21
	110	
	42	Renens (Vaud)
	47	Lausanne
	49	Pully
	52	Lutry
	54	Villette
	56	Cully
	57	Epesses
	61	Rivaz
	62	St-Saphorin
	66	**Vevey**
	67	La Tour-de-Peilz
	69	Burier
	71	Clarens
	72	Montreux
	73	Territet
	74	Veytaux-Chillon
	76	**Villeneuve**
	81	Roche (Vaud)
	85	Yvorne
	87	Aigle
	91	St-Triphon
	95	Bex
	97	Les Paluds
	99	**St-Maurice**
	105	Evionnaz
	109	Vernayaz
	114	Martigny
	118	Charrat-Fully
	122	Saxon
	126	Riddes
	129	Chamoson
	132	Ardon
	135	Châteauneuf
	139	**Sion (Sitten)**
	145	St-Léonard
	148	Granges-Lens
	155	Sierre (Siders)
	159	Salgesch (Salquenen)
	164	Leuk (Loèche)
	169	Turtmann (Tourtemagne)
	173	Gampel
	177	Baron (Rarogne)
	184	Visp (Viège)
	193	**Brig (Brigue)**
	204	Station du tunnel
	▲215	Iselle
	221	Varzo
	230	Preglia
	▲234	**Domodossola**

Fig. 9.

Lausanne-Vallorbe-Lausanne

Arrond. I.

Renfort de	No des lignes et des gares	Gares
6	7	21
	610	Train Nº
	47	**Lausanne**
	42	Renens
	40	Bussigny
	36	Vufflens-la-Ville
	32	Cossonay
	27	Daillens
	24	La Sarraz
	19	Arnex
	13	Croy-Romainmôtier
	4	Le Day
	1	**Vallorbe**
	110	Train Nº
	1	**Vallorbe**
	4	Le Day
	13	Croy-Romainmôtier
	19	Arnex
	24	La Sarraz
	27	Daillens
	32	Cossonay
	36	Vufflens-la-Ville
	40	Bussigny
	42	Renens
	47	**Lausanne**

Fig. 10.

Lausanne-St-Maurice

Arrond. I.

Renfort de	Nº des lignes et des gares	Gares
6	7	21
	110	
	42	Renens
	47	**Lausanne**
	49	Pully
	52	Lutry
	54	Villette (Vd)
	56	Cully
	57	Epesses
	61	Rivaz
	62	St-Saphorin
	66	**Vevey**
	67	La Tour-de-Peilz
	69	Burier
	71	Clarens
	72	Montreux
	73	Territet
	74	Veytaux-Chillon
	76	**Villeneuve**
	81	Roche (Vaud)
	85	Yvorne
	87	Aigle
	91	St-Triphon
	95	Bex
	97	Les Paluds
	99	**St-Maurice**

Fig. 11.

Figs. 9 to 13. — Columns of guard's journal giving the names of the stations and their numbering on the line.

Explanation of French terms in figures 9 to 14:

Arrond. = Ist Division. — Renfort de = Assisting from. — Nº des lignes et des gares = No. of the lines and of the stations. — Gares = Stations.

St-Maurice - Brigue

Arrond. I.

Renfort de	N° des lignes et des gares	Gares
6	7	21
	110	
	99	**St-Maurice**
	105	Evionnaz
	109	Vernayaz
	114	Martigny
	118	Charrat-Fully
	122	Saxon
	126	Riddes
	129	Chamoson
	132	Ardon
	135	Châteauneuf
	139	**Sion**
	145	St-Léonard
	148	Granges-Lens
	155	Sierre
	159	Salquenen
	164	Loèche
	169	Tourtemagne
	173	Gampel
	177	Rarogne
	184	**Viège**
	193	**Brigue**

Fig. 12.

Brigue-Sion-Brigue

Arrond. I.

Renfort de	N° des lignes et des gares	Gares
6	7	21
	610	Train N°
	193	**Brigue**
	184	**Viège**
	177	Rarogne
	173	Gampel
	169	Tourtemagne
	164	Loèche
	159	Salquenen
	155	**Sierre**
	148	Granges-Lens
	145	St-Léonard
	139	**Sion**
	110	Train N°
	139	**Sion**
	145	St-Léonard
	148	Granges-Lens
	155	**Sierre**
	159	Salquenen
	164	Loèche
	169	Tourtemagne
	173	Gampel
	177	Rarogne
	184	**Viège**
	193	**Brigue**

Fig. 13.

Figs. 9 to 13. — Columns of guard's journal giving the names of the stations and their numbering on the line.

Delle-Delémont-Bern-Thun

Kreis
Arrond. **I**

Vorspann oder Schiebe von / Renfort de	Linien- und Stations-Nr. / N° des lignes et des gares	Stationen / *Gares*
6	7	21
	123	
	1	**Delle**
	2	Boncourt
	4	Buix
	6	Grandcourt
	8	Courtemaiche
	10	Courchavon
	13	**Porrentruy**
	18	Courgenay
	24	St.-Ursanne
	29	Glovelier
	33	Bassecourt
	36	Courfaivre
	38	Courtételle
	41	**Delémont**
	44	Courrendlin
	46	Choindez
	49	Roches
	△52	**Moutier**
	63	Grenchen-Nord
	△65	Lengnau
	67	Pieterlen
	73	Mett-Bözingen
	77	**Biel-P.B. od. R.B.**
	124	
	1	**Biel-P.B. od. R.B.**
	4	Brügg
	8	Busswil
	11	**Lyss**
	15	Suberg
	19	Schüpfen
	25	**Münchenbuchsee**
	28	Zollikofen
	33	Wilerfeld
	35	**Bern-P. B.**
		» -W'haus
	125	
	1	**Bern-W'haus**
		» -P. B.
	3	Wilerfeld
	6	Ostermundigen
	9	Gümligen
	12	Allmendingen
	14	Rubigen
	17	Münsingen
	21	Wichtrach
	24	Kiesen
	27	Uttigen
	33	**Thun-G. B.**
		» -P. B.

Fig. 14. — Columns of guard's journal giving the names of the stations and their combined numbering on different lines.

figure 19 be analysed, it will be seen that the month is placed at the top horizontally in the column corresponding to its number. For example, the month of November is punched in column 11 above the heading « No. of the locomotive ». The date for which the card is perforated is the 3 November. The number of the train is perforated in columns (3-7). The columns (8-9) refer to the service of the locomotives and the class of the train. The number of the locomotive (columns 10-14), indicates its class as well as the number of the train — its kind (express, stopping, etc.). The columns (15-17) refer to the line worked over; the columns (18-20) to the kilometric index of the departure station; on this line, the columns (21-23) determine the index of the arrival station; finally, the columns (24-26) give the distance between the two stations concerned obtained by subtraction as we shewed above. The columns (27-35) are used for statistics concerning the number of axles of both Swiss and foreign vehicles required by the Swiss Railway Association at Berne. The columns (34-37) relate to the number of gross tons equal to the load of the train; for each alteration of the load of a train, a special card is punched. Finally, the columns (38-45) are used ultimately in the preparation of the statistics dealing with the number of passengers using the different classes of carriage.

The cards are perforated by means of *perforating machines* (fig. 20). By mechanical methods, the description of which is outside the scope of this article, the figures selected are placed in a horizontal line and are very easily read so that their position can be checked before punching the cards. The zeros are automatically punched without any setting. Certain groups of figures can be immobilised which makes the work of abstracting similar documents easier.

The perforated cards are automatically classified by means of *selecting machines* (fig. 21). To this end, about 500 cards are placed in a box which is filled as needed. The bottom cards are moved forward by a carriage fitted with twelve contact pins : every time a pin meets a punched hole, the passage corresponding to the box of the particular title opens and the card is placed in the box. When a title covers several columns, the cards are sorted as many times as there are columns, that is to say, the cards are sorted by units, tens, hundreds, thousands, etc., of the headings in question. When the sorting is finished, the figures on the cards are automatically counted up. The machine, called a *tabulator* (fig. 22) carries out the following operations :

1. Prints in columns on a statement the respective figures of each card;
2. Adds (vertically) the corresponding columns;
3. Adds (horizontally) the special subjects capable of being brought together.

By altering the columns and the headings required, all the summaries required by the statistical and other services for which statements are prepared can be obtained.

Statements.

When the abstracting of the guard's journals has been completed and the work on the figures contained therein thus prepared, the Statistical section at the Swiss Federal Railways General Headquarters puts in hand the preparation of the final abstracts which summarise the work of the system as regards Operating in general, and the locomotive and train mileage in particular.

At this time, the statistical work be-

Schweizerische Bundesbahnen
Chemins de fer fédéraux

Monat / Mois de Janvier 1928.

Verzeichnis der Personenfrequenzen — *Registre de la fréquentation des trains*

Tag · Jour	Zug / Train 36												36 WL.											
	ab dép Vallorbe an arr			ab dép Lausanne an arr			ab dép Sion an arr			ab dép Brigue an arr			ab dép Vallorbe an arr			ab dép Lausanne an arr			ab dép Sion an arr			ab dép Brigue an arr		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1	31	56	78	9	35	110	2	20	55	2	19	40	11			11			1			3		
2	18	46	74	18	46	96	3	24	22	3	28	26	6			4			2			0		
30																								
31	21	66	41	14	53	83	5	30	42	5	26	30	14			5			4			4		
Total	750	1422	2624	612	1210	3184							312											
Mittel Moy.	24	46	85	20	39	103							10											

Fig. 15. — Monthly summary of seats occupied in the carriages of the different classes, drawn up by the Divisional Headquarters of the Swiss Federal Railways.

Explanation of French terms : Mois de janvier 1928 = Month of January 1928. — Registre de la fréquentation des trains = Register of the passengers travelling by the trains. — Jour = Day. — Dep. = Departure. — Arr. = Arrival. — Moy. = Mean.

comes clearly divided so as to separate the periodical abstracts :

— for the locomotive mileage;
— for the train mileage.

The object of this article is to give a general view of the preparation and make-up of the statistical tables for each of the above branches.

The *table of the locomotive mileage* is made out monthly. To prepare it, it is necessary to calculate, for each engine and each class of work :

— the mileage per trip;
— the number of trips;
— the gross load per trip.

Then by multiplying :

— the mileage of the trips

by

— the number of the trips

we get :

— *the total locomotive mileage*

run by the locomotive in question and by all the locomotives, separately for each kind of service.

Mileage of locomotives.

Kind of service of locomotive.	Number of the locomotive.	Kilometres.	Number of trips.	Tonnage.
1	1.740	109	12	6 860
1	1.740	138	5	2 515
1	1.740	143	2	960

Fig. 16. — Statement for the statistics of locomotive mileage, made up with the tabulating machine.

This total multiplied in its turn by :

— the gross tonnage of all the trips, gives :

— *the total gross ton-kilometres* run by all the locomotives of the system.

By calculation we then get :

— the *average load* of the locomotives working trains of all kinds, and assisting.

The table (fig. 23) is the monthly summary of the work done by the locomotives of the Swiss Federal Railways.

The *table of the train journeys is prepared quarterly.* It gives for each kind of train :

— the number of trains;

— the number of train-kilometres;

— the number of axle-kilometres;

— the number of gross ton-kilometres.

To prepare this table, the tabulating machine makes two summaries of the train journeys by *line* and *class of service,* as follows :

— a table of the journeys made by the trains classified under the *departure station* (fig. 24);

— a table of the journeys made by the trains classified under the *arrival station* (fig. 25).

Based on these two summaries, a monthly table (fig. 26) is got out for each line and category of train, giving the *kilometric output from station to station* and shewing in :

— number of trains;

— number of axles;

— number of journeys;

— number of tons,

the *kilometric output* of each section (figs. 27, 28 and 29) between two following stations on the line.

The table shews the standard three-monthly summary (fig. 30) of the kilometric journeys of the trains on the Swiss Federal Railway System.

This presentation of the exact figures of the traffic enables a concise analysis to be made of the essential factors in the output of the line, expressed on the shortest possible journeys, *i. e.*, on the distance between any two stations (figs. 27 to 29).

* * *

In order to bring together this output of the lines and sections of line of the system, the Statistical section at Berne publishes at the end of each half year and of each year, a general statement of the intensity of traffic per line and section of line. This statement gives for each line (see table, fig. 36).

— the number of *train-kilometres;*

— the number of *trains per kilometre* of line;

— the number of axle-kilometres;

— the number of *axles per kilometre* of line;

— the number of *gross ton-kilometres;*

— the number of *gross tons per kilometre* of line.

(See figs. 31 to 35).

Zugbelastungstabelle.

Linie / Ligne	Vallorbe - Renens (Lausanne)									
Züge / Trains No.	4303		4305		4306		4309		4312	
Strecke / Section	Dép.		Dép.		Dép.		Dép.		Dép.	
Norm: / Charge maximum	T. Ren.	T. Vall.	T. Ren.	T. Vall.	T. Vall.	T. Ren.	T. Ren.	T. Vall.	T. Vall.	T. Ren.
Tag / Jour:	T	T	T	T	T	T	T	T	T	T
1	361		167		153		100		657	
2	129		225		395		312		578	
3										
31	150		192		418		284		843	
Total:	5239		4781						21843	
Mittel: / Moyenne:	169		154						705	

Fig. 17. — Tab

Explanation of French terms: Tableau de la charge des trains = Table of loads of trains.

Kreis - *Arrond.* I

ETAT DES RETARDS

Tag / *Jour*	Ab Abgangsstation / *Dès la station de départ*	Auf Endstation / *A l'arrivée à la station terminus*	Verspätete Anschlusszüge / *Trains correspondants retardés* — fremder Verwaltungen und anderer Kreise / *provenant d'autres administrations ou d'autres arrondissements* — Min.	Züge No. / *Trains No.*	eigene / *provenant de son propre arrondissement* — Min.	Züge No. / *Trains No.*	Unfälle / *Accidents*	Athmosphär. Einflüsse / *Influences athmosphériques*	Rollmaterialdefekte / *Avaries au matériel roulant*	Zoll- und Grenzdienst / *Service douanier et de frontière*	Postdienst / *Service postal*	Fahrdienst / *Service de la traction*	Umbau u. Langsamfahrsignale / *Réfections de voies et signaux de ralentissement*	Verspätete Kreuzungs- und Überholungszüge / *Trains croiseurs et trains à dépasser ou dépassant retardés* — Min.	Züge No / *Trains No*	Stationsdienst / *Service des gares* — Min.	Stationen - *Gares*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
11	81	10							18	3	36.					–	Vallorbe
8	8	18	2	ant^{r}							343.	6	3	10	143	–	Porrentruy
1	11	7			11	1446					1040.					6	diverses
9	5	16			5	1417					1320.			6	118	5	diverses

Fig. 18. — Monthly statement of delays to trains, drawn u

Explanation of French terms: Etat des retards des trains du 1er au 31 janvier 1928 = Statement
leaving the departure station. — A l'arrivée à la station terminus = On arrival at the terminus
ou d'autres arrondissements = Other companies or divisions. — Provenant de son propre arro
au matériel roulant = Rolling stock defects. — Service douanier et de frontière = Customs. — S
de ralentissement = Permanent way and signal repairs. — Trains croiseurs et trains à dépasser
at stations. — Gares = Stations. — Justification = Reason. — Correspondances manquées = M

bleau de la charge des trains.

Monat / *Mois de* Janvier 1928

III. A. Nr. 35 a.

										4346		4349		
										Dép.		Dép.		
T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T. Kall.	T. Rer	T. Rer.	T. Kall.	
T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	T.	Tag *Jour.*
										414		328		1
										586		242		2
														3
														30
										415		312		31
										18214		8125		
										588		262		

s of trains.

Line. — Charge maximum = Maximum load. — Jour = Day. — Moyenne = Average.

TRAINS du 1 au 31 JANVIER 1928.

Begründung *Justification*	Versäumte Anschlüsse *Correspondances manquées* von *de*	an *à*	Bemerkungen *Observations*
19	20	21	22
placement d'une voiture avariée			
se d'eau			
hargement du lait			
rgement des colis GV.			

Divisional Headquarters of the Swiss Federal Railways.

o trains from the 1 to 31 January 1928. — Jour = Day. — Dès la station de départ = On
Trains correspondants retardés = Connecting trains late. — Provenant d'autres administrations
= In the division itself. — Min. = Minutes. — Influences athmosphériques = Weather. — Avaries
= Post office. — Service de la traction = Locomotive dept. — Réfections de voies et signaux
t retardés = Trains crossing and trains to pass or passing late. — Service des gares = Work
ctions. — De = From. — A = To. — Observations = Notes.

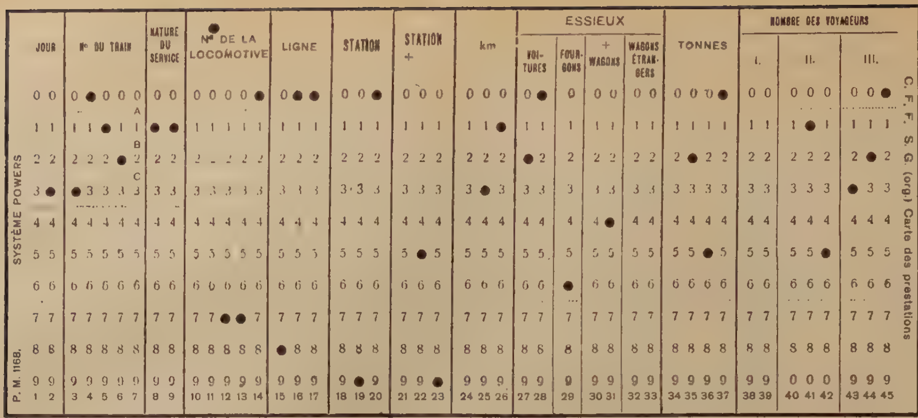


Fig. 19.— Perforated card for mileage statistics, in use on the Swiss Federal Railways.

Explanation of French terms (from left to right) : Powers system. — Day. — Train No. — Kind of service — No. of the locomotive. — Line. — Station. — Station +. — Kilometres. — Axles. — Carriages. — Brakes. Wagons. — Foreign wagons. — Tons. — Number of passengers. — Ist class. — IInd class. — IIIrd class — Swiss Federal Railways S. G. (org.) Data card.

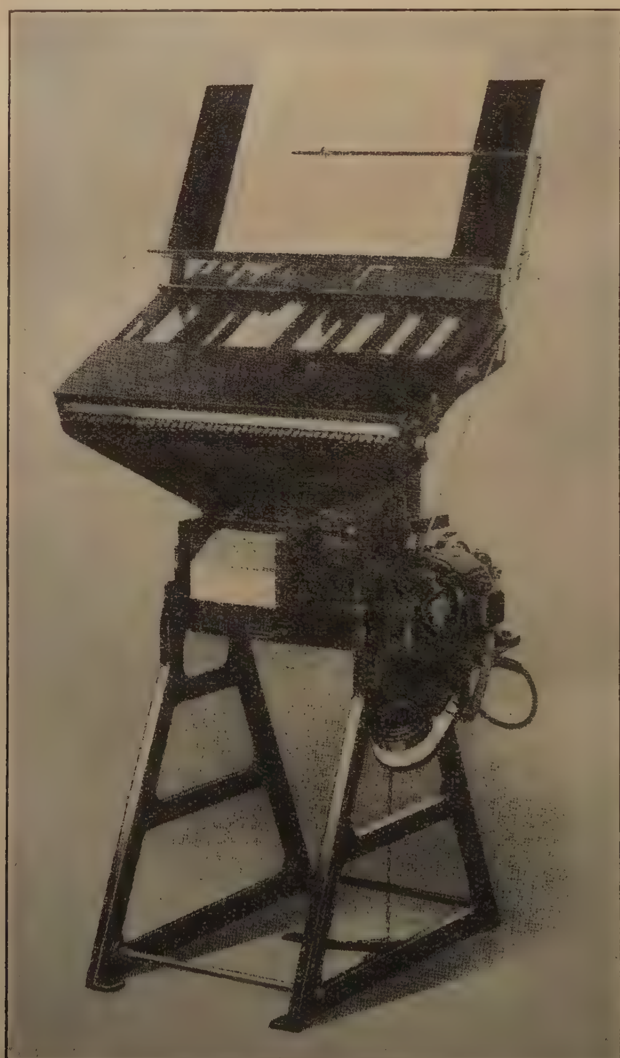


Fig. 20. — Perforating machine.

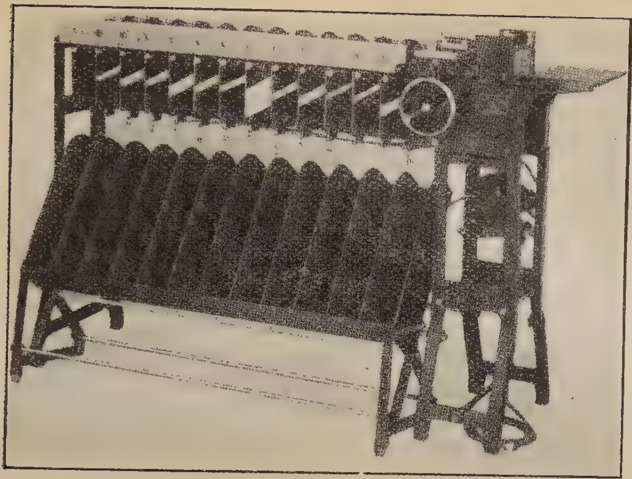


Fig. 21. — Selecting machine.

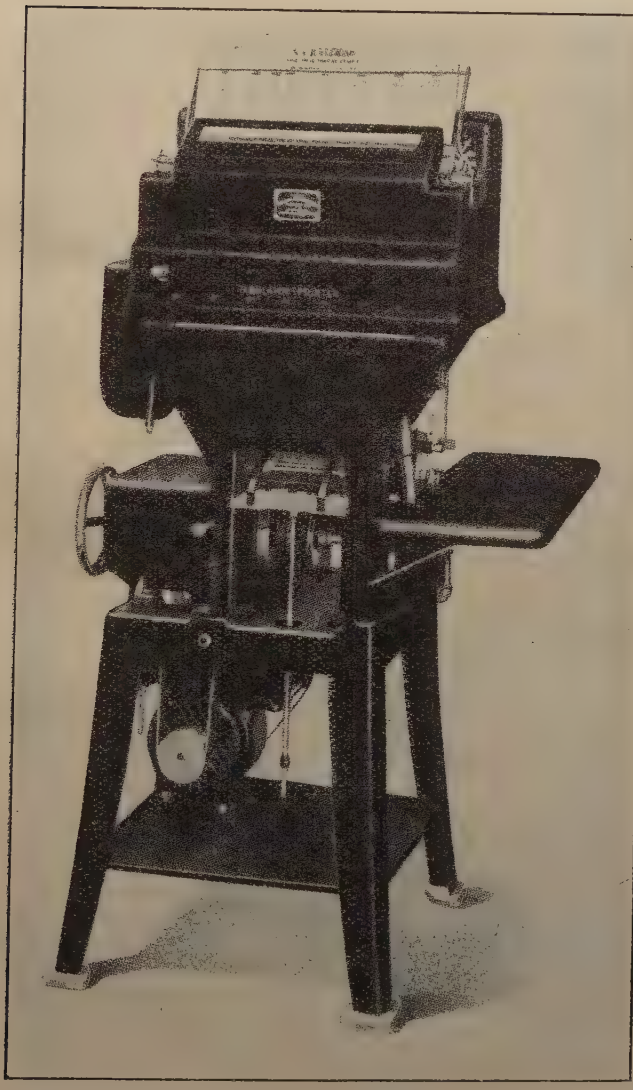


Fig. 22. — Tabulator.

Fig. 23. — Monthly statement of the locomotive mileages, drawn up by the Statistical Section of the Swiss Federal Railways, at Berne.

Explanation of French terms : Chemins de fer Fédéraux. Section de statistique = Swiss Federal Railways. Statistical Section. — Parcours approximatifs des locomotives CFF., au cours du mois de... = Approximate mileage of Swiss Federal Railway locomotives during the month of... — (Réseau CFF., lignes affermées, lignes exploitées et lignes étrangères) = (Swiss Federal Railway system, lines ceded, lines operated and foreign lines). — Traction à vapeur = Steam traction. — Traction électrique = Electric traction. — Voie étroite = Narrow gauge. — Traction à vapeur (voie étroite non comprise) = Steam traction (narrow gauge not included). — Traction électrique (tracteurs divers non compris) = Electric traction (various tractors excluded. — 1er Arrond. °/o = 1st Division °/o. — 2e Arrond. °/o = 2nd Division °/o. — 3e Arrond. °/o = 3rd Division °/o. — Longueurs exploitées (y compris les lignes affermées et exploitées) = Length operated (including lines ceded and operated). — Kilomètres-locomotives = Locomotive-kilometres. — Tonnes kilométriques brutes = Gross ton-kilometres. — Charges moyennes des locomotives du service des trains, etc. = Average load of train, assisting and service locomotives.

Conclusion.

We have endeavoured to outline the *rational methods* in use on a large railway system so as to establish *a system of mileage statistics* taken for the general *organisation of work* of this system.

We have given in this article in their sequence the *fundamental* bases of organisation of this work, bringing out especially the essential idea which has made it possible to complete it with a clearness, facility and speed unparalleled.

If the immense effort accomplished by the Swiss Federal Railways in regard to the *simplification of the work* in all the *administrative and technical* branches is considered, it must be admitted that the *spirit of re-organisation* presumed by the Swiss legislation of 1923 has entirely favoured the *unification of technical methods* in the *direction of the standardisation of the work* in order to *facilitate by technical processes*, such as *automatic and mechanical methods*, the work of the staff. In this particular case, this study of the organisation of the Statistical Service of the Swiss Federal Railways shews that the *centralisation* of all *statistics relating to the journeys made by the engines, trains and railway stock* makes it possible to effect important savings, both as regards *time* and *cost*.

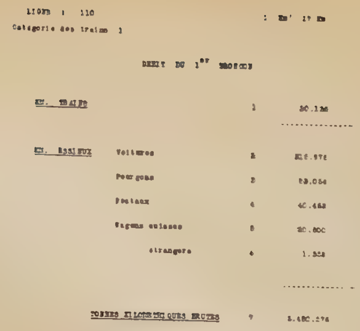
Furthermore, the same *concentration* enables all *work* known as *double purpose* to be avoided, which appreciably *simplifies* the *processes* and enormously *accelerates* the handling of the papers in question and the *preparation* of the *final results* the different services ask for at the same time.

The example of the Swiss Federal Railways can be used throughout as the *type of rational organisation* for a statistical service which is required to be *simple, quick* and *inexpensive*.


PARCOURS DES TRAINS

1er TABLEAU

Fig. 24. — Abstract (made up on the tabulator) of the train mileage statistics according to the station of *departure*


LIGNE : 110

Catégorie des trains 1

DEBIT DU 1er TRONÇON

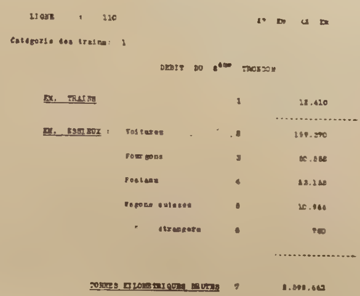
TONNES KILOMETRIQUES BRUTES

Fig. 27.


PARCOURS DES TRAINS

IIème TABLEAU

Fig. 25. — Abstract (made up on the tabulator) of the train mileage statistics according to the station of *arrival*.


LIGNE : 110

Catégorie des trains 1

DEBIT DU 2ème TRONÇON

TONNES KILOMETRIQUES BRUTES

Fig. 28.


PARCOURS DES TRAINS

IIIème TABLEAU

Fig. 26. — Abstract (made up on the tabulator) of the train mileage statistics between various stations on a line.


LIGNE : 110

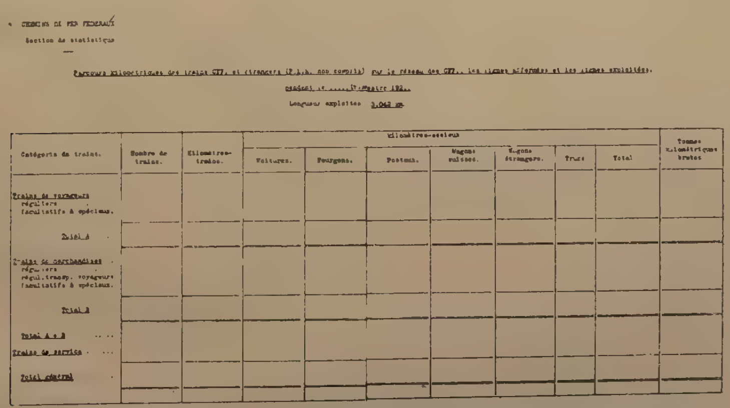
Catégorie des trains 1

DEBIT DU 3ème TRONÇON

TONNES KILOMETRIQUES BRUTES

Fig. 27.

Figs. 27 to 29. — Abridged abstracts of the output of a section of line.


CHEMINS DE FER FEDERAUX

Section de statistique

Longueur exploitée 3.042 km

Catégorie de trains.	Nombre de trains.	Kilomètres-trains.	Kilomètres-essieux: Voitures.	Fourgons.	Postaux.	Wagons suisses.	Wagons étrangers.	Trucs	Total	Tonnes kilométriques brutes
Trains de voyageurs réguliers facultatifs & spéciaux.										
Total A										
Trains de marchandises réguliers régul. transp. voyageurs facultatifs & spéciaux.										
Total B										
Total A + B										
Trains de service										
Total général										

Fig. 30. — Standard three-monthly summary of the train mileage on the Swiss Federal Railways, drawn up by the statistical section, at Berne.

Tableau des parcours

	Parcours						
	Trains réguliers		Trains facultatifs et spéciaux		Total service des trains		
	voyageurs	marchandises (trains mixtes y compris)	voyageurs	marchandises	1926	*1925*	
Locomotives C F F sur réseau C F F (Vevey-Chexbres, Nyon-Crassier, ligne de raccordement [trains C F F] et du Brünig y compris) . . .	23 025 588	9 285 104	383 528	618 243	33 312 463	*31 814 656*	1
Locomotives C F F sur lignes exploitées et étrangères.							
a. sur lignes exploitées:							
Bulle-Romont	41 436	11 124	36	720	53 316	*53 010*	2
Moutier-Longeau, B L S	92 587	48 085	676	1 248	142 596	[illegible]	
...Etat allemand							23
Total locomotives C F F sur reseau C F F, lignes affermées, exploitées et étrangères	23 454 570	9 538 145	385 274	628 790	34 006 779	*32 459 268*	24
Locomotives C F F sur réseau C F F (Vevey-Chexbres, Nyon-Crassier, ligne de raccordement [trains C F F] et Brünig y compris).	23 025 588	9 285 104	383 528	618 243	33 312 463	*31 814 656*	25
Locomotives étrangères sur réseau C F F							
Paris-Lyon-Méditerranée	128 906	42 197	334	11 297	182 734	*178 467*	26
Berne-Lötschberg-Simplon	.		82	.	82	.	27
Berne-Neuchâtel	.	.	54		54	.	28
Bodensee-Toggenbourg	104 965		219	135	105 319	*104 800*	
							45
							46
Total locomotives C F F et étrangères sur réseau C F F et lignes affermées	23 281 995	9 332 109	384 795	630 840	33 629 739	*32 120 814*	47
Ces parcours se répartissent comme suit							
a. propre réseau (voie normale)	22 831 197	9 266 466	380 416	619 861	33 097 940	*31 629 493*	48
b. Vevey-Chexbres	40 880				40 880	*38 400*	49
c. Nyon-Crassier	17 520				17 520	*17 520*	50
d. Ligne de raccordement de Bâle (trains C F F) . .	13 000	25 860	615	1 995	41 470	*46 308*	51
d. Ligne de raccordement de Bâle (trains de l'Etat allem.)	17 780	3 580	575	1 155	23 090	*16 405*	52
e. Brunig (voie étroite)	361 618	36 203	3 189	7 829	408 839	*372 688*	53

Fig. 31. — Final yearly statement

Explanation of

Tableau des parcours des locomotives = Table of locomotive mileage. — Parcours utile = Working mileage. — Autres
— Marchandises (trains mixtes y compris) = Goods (including mixed trains). — Trains facultatifs et spéciaux = Special trains.
tête et en queue = Assisting at head and in rear. — Trains voyageurs = Passenger. — Trains marchandises = Goods. —
working. — Service des manœuvres (1 heure = 6 km.) = Shunting (1 hour = 6 kilometres). — Total général = General total.
system (Vevey-Chexbres, Nyon-Crassier, connecting line [S. F. Railway trains] and of the Brünig included). — Locomotives
tées, etc. = *a.* on lines operated. — ***Middle*** : Total locomotives CFF sur réseau CFF, lignes affermées, exploitées et étran-
sur réseau CFF (Vevey Chexbres, etc.) = S. F. Railway locomotives on S. F. Railway system (Vevey-Chexbres, Nyon-
Lyon-Mediterranée. Berne-Lötschberg Simplon, Berne-Neuchâtel, Bodensee-Toggenbourg = Foreign locomotives on S. F.
Total locomotives CFF et étrangères sur réseau CFF et lignes affermees = Total locomotives of S. F. Railways and foreign
normale, etc. = These mileages are distributed as follows. *a.* own system (standard gauge); *b.* Vevey-Chexbres; *c.* Nyon-

des locomotives

	utile				Autres parcours		Total, service des lignes		Service des manœuvres (1 heure = 6 km)	Total général	
	Renfort en tête et en queue		Total		trains de service	haut-le-pied					
	trains voyageurs	trains marchandises	1926	*1925*			1926	*1925*		1926	*1925*
1	1 006 797	514 748	34 834 008	*32 627 794*	228 261	1 045 474	36 107 743	*34 477 797*	5 450 665	41 558 408	*39 895 002*
2	54	90	53 460	*53 046*	54	126	53 640	*53 136*	2 672	56 312	*55 627*
23		329	329	*176*		329					
24	1 034 272	543 904	35 584 955	*33 317 315*	242 081	1 077 643	36 904 679	*35 216 262*	5 459 729	42 364 408	*40 641 538*
25	1 006 797	514 748	34 834 008	*32 627 794*	228 261	1 045 474	36 107 743	*34 477 797*	5 450 665	41 558 408	*39 895 002*
26	7 559	2 857	193 150	*186 968*	21	9 917	203 088	*198 343*	.	203 088	*198 607*
27			82		36		118	*32*		118	*32*
28			54	.	54		108	.	.	108	.
										105 619	*105 746*
46			.		.	39	39	—	.	39	
47	1 014 612	517 971	35 162 322	*32 944 392*	229 722	1 059 216	36 451 310	*34 810 584*	5 450 665	41 901 975	*40 228 053*
48	971 862	516 366	34 586 168	*32 417 365*	226 170	1 046 880	35 859 218	*34 267 946*	5 400 312	41 259 530	*39 637 461*
49	16		40 896	*38 400*	38	8	40 942	*38 400*	.	40 942	*38 400*
50			17 520	*17 520*	12		17 532	*17 556*	.	17 532	*17 556*
51	235	805	42 510	*46 633*	117	1 353	43 980	*49 174*	.	43 980	*49 174*
52	30	275	23 395	*17 550*	595	2 570	26 560	*21 230*	.	26 560	*21 230*
53	42 469	525	451 833	*406 924*	2 840	8 405	463 078	*416 278*	50 353	513 431	*464 232*

of locomotive mileage.

French terms :

parcours = Other mileage. — *Second column and onward* : Trains réguliers = Booked trains. — Voyageurs = Passenger. — Voyageurs = Passenger. — Marchandises = Goods. — Total service des trains = Total train service. — Renfort en Total = Total. — Trains de service = Service trains. — Haut-le-pied = Light. — Total, service des lignes = Total line — *First column. Top* : Locomotives CFF sur réseau CFF (Vevey-Chexbres) = S. F. Railway locomotives on the S. F. Railway CFF sur lignes exploitées et étrangères = S. F. Railway locomotives, lines operated and foreign. — *a.* sur lignes exploigères = Total S. F. Railway locomotives on S. F. Railway system, lines leased, operated and foreign. — Locomotives CFF Crassier, connecting line [S. F. Railway trains] and Brünig included). — Locomotives étrangères sur réseau CFF : Paris-Railways : Paris-Lyons-Mediterranean, Berne-Lötschberg-Simplon, Berne-Neuchâtel, Bodensee-Toggenbourg. — *Bottom* : systems on S. F. Railway system and lines leased. — Ces parcours se répartissent comme suit : *a.* propre réseau (voie Grassier ; *d.* Junction line of Bale (S. F. Railway trains and German Railway trains); *e.* Brünig (narrow gauge).

Parcours kilométrique d

Série et numéro	Nombre moyen des locomotives en service pendant l'année	Service des lignes			
		service des trains	service de renfort	trains de service	haut-le-pied
		km	km	km	km
Locomotives à vapeur, voie normale					
A 2/4 109 ...128	0,2	55	392	—	—
A 3/5 501—502	2,0	60 304	5 090	99	1 084
601—649	49,0	3 165 776	48 111	2 686	39 208
E 4/4 8801—8802	2,0	63	-	—	71
8851—8856	6,0	320	736	120	122
	723,7	17 819 483	549 048	146 510	342 521

Fig. 32. — Final yearly statem

Explanation of French terms : Parcours kilométrique, etc. = Mileage run by steam locomotives. — Série et numéro =
en service pendant l'année = Average number of the locomotives in service during the year. — Service des lignes =
Haut-le-pied = Light. — En tout = Total. — Service des manœuvres (1 heure = 6 km.) = Shunting (1 hour = 6 km.) -
ton-kilometres = En tout (locomotives non comprises) = As a whole, locomotives not included. — Par kilometre utile =

Parcours kilométrique des lo

Série et numéro	Nombre moyen de locomotives en service pendant l'année	Service des lignes			
		service des trains	service de renfort	trains de service	haut-le-pied
		km	km	km	km
		A. Locom			
Ae 3/5 10201—10226 . .	26,0	1 766 595	65 489	8 810	88 950
Ae 3/6 10261—10271 . .	8,2	499 127	9 852	2 548	21 224
Ae 3/6 10401—10460 . .	56,7	2 923 175	115 999	14 891	24 052
10601—10676 . .	62,3	3 981 931	174 137	12 572	96 575

Fig. 33. — Final yearly statement c

Explanation of French terms : Parcours kilométrique, etc. = Kilometres run by electric locomotives and motor coaches. — A. and

Parcours kilométrique

Parcours des trains C F F et étrangers sur les lignes des C F F,

Sections	Longueur en kilomètres	1926				
		Express et omnibus			Trains réguliers de marchandises avec voyageurs	
		réguliers	facultatifs et spéciaux	en tout		
1	2	3	4 km-trains	5	6	
I. Propres lignes (Vevey-Chexbres et Nyon-Crassier y compris)						
a. Voies normales						
La Plaine-Genève (trains P L M y compris). .	15	188 000	585	188 585	—	1
Genève-Lausanne	60	936 927	8 247	945 174	—	2
Lausanne-Fribourg-Berne P. B.	97	762 403	10 409	772 812	—	3
Renens Fribourg-Berne W'haus & P B. . . .	102	—	—	—	11 204	4
Lausanne Neuchâtel-Bienne	103	750 871	7 840	758 711	—	5
Nyon-Crassier-La Rippe (frontière)	6	17 520	—	17 520	—	6
Vallorbe (frontière)-Vallorbe gare (trains P L M)	3	6 576	—	6 576	—	7
Vallorbe gare-Lausanne	46	311 957	1 024	312 981	14 360	8
Lausanne-St-Maurice	52	633 246	25 162	658 408	—	9
St-Maurice-Iselle transit	116	946 128	19 519	965 647	33 804	10
Le Pont-Vallorbe gare	[illegible]	[illegible]	[illegible]	35 004	—	11
Vevey-Puidoux-Chexbres	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Fig. 34. — Final yearly

Explanation of French terms : Parcours kilométrique, etc. = Kilometres run by the trains. — Parcours des trains C. F. F
leased or operated. — Km.-trains = Train-kilomètres. — I. Propres lignes = I. Own lines. — *a.* Voies normales. — *a.*
= Booked. — Facultatifs et spéciaux = Special. — En tout = Whole. — Trains réguliers de marchandises avec voyageurs = ve
passengers. — Par km. de voie = Per kilometre of line. — Total des trains = Total for the trains.

omotives à vapeur

Service des manœuvres (1 heure = 6 km)	Total du service effectué	Par locomotive 1926	Par locomotive 1925	Tonnes-kilomètres brutes en tout (locomotives non comprises)	Tonnes-kilomètres brutes par kilomètre utile 1926	Tonnes-kilomètres brutes par kilomètre utile 1925
km	km	km	km	t-km	t-km	t-km
—	447	2 335	*11 541*	64 315	143	*173*
541	67 118	33 559	*25 750*	14 285 673	218	*249*
6 279	3 262 060	66 573	*73 749*	806 042 915	251	*269*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	193	*210*
55 483	55 617	27 809	*26 553*	10 614	168	[illegible]
159 402	160 700	26 783	*30 660*	376 424	356	*322*
4 999 636	23 857 198	32 966	*30 004*	4 045 137 234	220	*235*

the steam locomotive mileage.

number. — Locomotive à vapeur, voie normale = Steam locomotives, standard gauge. — Nombre moyen des locomotives ce. — Service des trains = Train service. — Service de renfort = Assisting service. — Trains de service = Service trains. — u service effectué = Total of the work done. — Par locomotive = Per locomotive. — Tonnes-kilomètres brutes = Gross ul kilometre.

tives et automotrices électriques

	Service de manœuvres (1 heure = 6 km)	Total du service effectué	Par locomotive 1926	Par locomotive 1925	Tonnes-kilomètres brutes en tout (locomotives non comprises)	Tonnes-kilomètres brutes par kilomètre utile 1926	Tonnes-kilomètres brutes par kilomètre utile 1925
	km	km	km	km	t-km	t-km	t-km
es et automotrices électriques							
motives à courant monophasé							
4	53 036	1 982 880	76 265	*84 900*	484 910 799	265	*281*
1	10 274	543 025	66 222	*17 596*	137 414 669	270	*282*
7	23 598	3 101 715	54 704	*51 343*	751 879 621	247	*271*
5	[illegible]	4 293 146	68 911	[illegible]	[illegible]	[illegible]	[illegible]

ic locomotives and motor coaches.

otives, etc. = A. Electric locomotives and motor coaches. *a.* Monophase locomotives. — *Columns* : Same headings as in figure 32.

des trains

ainsi que sur les lignes affermées ou exploitées

	1926									*1925*	
	Trains de marchandises sans voyageurs			Trains réguliers		Trains facultatifs et spéciaux		Total des trains		*Total des trains*	
	réguliers	facultatifs et spéciaux	en tout	en tout	par km de voie	en tout	par km de voie	en tout	par km de voie	*en tout*	*par km de voie*
	7	8	9	10	11 km trains	12	13	14	15	16	17
1	47 998	10 155	58 153	235 998	15 733	10 740	716	246 738	16 449	*234 248*	*15 617*
2	223 125	8 267	231 392	1 160 052	19 334	16 514	275	1 176 566	19 609	*1 083 702*	*18 060*
3	—	—	—	973 616	P 7 860	18 818	107	992 434	7 967	*914 565*	*7 811*
4	200 009	8 409	208 418		G 2 071		82		2 153		*1 538*
5	404 115	4 267	408 382	1 154 986	11 213	12 107	118	1 167 093	11 331	*1 073 444*	*10 421*
6	—	—	—	17 520	2 920	—	—	17 520	2 920	*17 520*	*2 920*
7	—	6	6	6 576	2 192	6	2	6 582	2 194	*6 570*	*2 190*
8	136 952	1 155	138 107	463 269	10 071	2 179	47	465 448	10 118	*431 185*	*9 373*
9	[illegible]	7 623	199 462	825 085	15 867	32 785	630	857 870	16 497	*831 393*	*15 988*

nt of train mileage.

ilometres run by Swiss Federal Railways and other Companies' trains on the Swiss Federal Railway lines and on lines gauge. — Longueur en kilomètres = Length in kilometres. — Express et omnibus = Express and stopping. — Réguliers = Booked goods trains conveying passengers. — Trains de marchandises sans voyageurs = Goods trains not conveying

I. Lignes C F F	Voitures		Fourgons	Ambulants postaux	
	km-essieux	Nombre moyen d'essieux d'un train	km-essieux	km essieux	
	1	2	3	4	
1. Voie normale					
a. Trains C F F					
Trains de voyageurs:					
à traction à vapeur	186 522 473		35 380 846	19 604 919	1
» » *électrique*	214 053 159	.	34 290 804	22 363 515	2
Total	400 575 632	17,43	69 671 650	41 968 434	3
Trains mixtes et trains de marchandises:					
à traction à vapeur	9 653 605		5 908 145	342 958	4
» » *électrique*	5 962 537		3 903 732	1 032 368	5
Total	15 616 142	1,59	9 811 877	1 375 326	6
Trains de service:					
à traction à vapeur	1 502 966	.	202 714	3 088	7
» » *électrique*	1 353 144	.	107 546	7 467	8
Total	2 856 110	12,67	310 260	10 555	9
Total, trains C F F	419 047 884	.	79 793 787	43 354 315	10
b. Trains étrangers [1]					
Trains de voyageurs	3 838 626	14,90	1 227 799	141 073	11
» mixtes et trains de marchandises	37 611	0,63	120 048	535	12
» de service	13 220	22,22	2 340	140	13
Total, trains étrangers	3 889 457	.	1 350 187	141 748	14
Total, voie normale	422 937 341		81 143 974	43 496 063	15
Ensemble des parcours sur lignes CFF, affermees et exploitees	433 857 805	.	83 741 289	44 300 316	64
Dont, parcours des trains CFF	429 968 348	.	82 391 102	44 158 568	65
» » » » étrangers	3 889 457	.	1 350 187	141 748	66
Nombre journalier moyen d'essieux sur le réseau entier (lignes CFF et affermées)	399,47	.	76,78	40,82	67

Fig. 55. — Final yearly statement showing mileage

Explanation of

First column (not numbered): Parcours des trains, etc. = Mileage run by trains and wagons or axle-kilometres. — Km.-essieux Federal Railway Lines. — 1. Voie normale = 1. Standard gauge. — *a.* Trains C F F = *a.* Swiss Federal Railway trains. — Trains trains de marchandises = Mixed and goods trains. — Trains de service = Service trains. — Total, trains C F F = Total Swiss panies trains. — Total, voie normale = Total standard gauge. — Ensemble des parcours sur lignes C F F, affermées et exploitées Federal Railway trains. — Dont, parcours des trains étrangers = Of which foreign trains. — Nombre journalier moyen d'essieux and leased lines). — *Columns 1 to 13*: Voitures = Carriages. — Fourgons = Brakes. — Ambulants postaux = Post Office vans. — wagons. — Total fourgons, ambulants postaux, wagons à marchandises, de service et de chauffage) = Total (brakes, Post Office

wagons ou km-essieux

	Wagons (de service, privés et trucs transporteurs y compris)				Wagons de chauffage	Total fourgons, ambulants postaux, wagons à marchandises, de service et de chauffage		Ensemble des wagons			
	suisses	étrangers	Total					1926		*1925*	
	km-essieux	km-essieux	km-essieux	Nombre moyen d'essieux d'un train	km-essieux	km-essieux	Nombre moyen d'essieux d'un train	km-essieux	Nombre moyen d'essieux d'un train	km-essieux	Nombre moyen d'essieux d'un train
	5	6	7	8	9	10	11	12	13	14	15
1	26 596 844	3 455 463	30 052 307	.	—	85 038 072	.	271 560 545	.	*313 731 629*	.
2	23 873 443	2 358 775	26 232 218	.	2 275 932	85 162 469	.	299 215 628	.	*228 770 121*	.
3	50 470 287	5 814 238	56 284 525	2,45	2 275 932	170 200 541	7,40	570 776 173	24,83	*542 501 750*	*23,88*
4	116 112 157	115 403 694	231 515 851	.	—	237 766 954	.	247 420 559	.	*281 379 846*	.
5	105 432 737	200 881 883	306 314 620	.	—	311 250 720	.	317 213 257	.	*239 909 060*	.
6	221 544 894	316 285 577	537 830 471	54,55	—	549 017 674	55,[illegible]	564 633 816	57,27	*521 288 906*	*56,09*
7	1 002 499	36 029	1 038 528	.	—	1 244 330	.	2 747 296	.	*2 543 540*	.
8	322 605	208 778	531 383	.	—	646 396	.	1 999 540	.	*1 747 319*	.
9	1 325 104	244 807	1 569 911	6,97	—	1 890 726	8,39	4 746 836	21,06	*4 290 859*	*15,18*
10	273 340 285	322 344 622	595 684 907	.	2 275 932	721 108 941	.	1 140 156 825	.	*1 068 081 515*	.
11	220 280	471 760	692 040	2,68	—	2 060 912	8,00	5 899 538	22,90	*5 629 543*	*21,81*
12	772 178	2 440 847	3 213 025	53,91	—	3 333 608	55,93	3 371 219	56,56	*3 192 575*	*68,82*
13	160	1 115	1 275	2,14	—	3 755	6,31	16 975	28,53	*30 099*	*33,08*
14	992 618	2 913 722	3 906 340	.	—	5 398 275	.	9 287 732	.	*8 852 217*	.
15	274 332 903	325 258 344	599 591 217	.	2 275 932	726 507 216	.	1 149 444 557	.	*1 076 933 732*	.
64	279 546 699	334 783 676	614 330 375	.	2 275 932	744 647 912	.	1 178 505 717	.	*1 104 587 936*	.
65	278 554 081	331 869 954	610 424 035	.	2 275 932	739 249 637	.	1 169 217 985	.	*1 095 735 719*	.
66	992 618	2 913 722	3 906 340	.	—	5 398 275	.	9 287 732	.	*8 852 217*	.
67	257,70	302,93	560,63	.	2,12	680,35	.	1 079,82	.	*1 012,01*	.

run by trains and rolling stock (axle-kilometres).

French terms :

= Axle-kilometres. — Nombre moyen d'essieux d'un train = Average number of axles per train. — I. Lignes C F F. = I. Swiss de voyageurs à traction à vapeur. à traction électrique = Passenger trains, steam traction, electric traction. — Trains mixtes et Federal Railway trains. — *b.* Trains étrangers = *b.* Foreign Companies trains. — Total. trains étrangers = Total Foreign Com- = Total on the Swiss Federal Railway lines and leased and operated lines. — Dont, parcours des trains C F F = Of which Swiss sur le réseau entier (lignes C F F et affermées) = Average daily number of axles on the whole system (Swiss Federal Railways Wagons (de service, privés et trucs transporteurs y compris) = Wagons (service included). — Wagons de chauffage = Heating vans, wagons goods, service and heating). — Ensemble des wagons = Total for the wagons.

Intensity of traffic duri

(Service trai

Kilometers run by Swiss Federal Railway trains and oth

Notes. — Lines mark

Line No.	COMMON LINES.	LINE.	Length operated.
		FIRST DIVISION	
		I. — **Swiss Federal Railway lines and lines ceded.**	
100	...	*La Plaine — Geneva.*	15
101	...	*Geneva — Lausanne* *	60
		a) Geneva - Renens	55
	102*a*, 103*a*, 110*c*, 130*a*.	*b*) Renens — Lausanne	5
102	...	*Renens — Lausanne — Fribourg — Berne* * *W'haus & HB.*	102
	101*b*, 103*a*, 110*c*, 130*a*.	*a*) Renens — Lausanne	5
	130*b*.	*b*) Lausanne — Palézieux-station	20
		c) Palézieux-station — Fribourg	47
		d) Fribourg — Berne W'haus & HB.	30
103	...	*Lausanne — Neuchâtel — Bienne*	103
	101*b*, 102*a*, 110*c*, 130*a*.	*a*) Lausanne — Renens *.	5
	110*b*.	*b*) Renens — Daillens *	15
		c) Daillens — Yverdon *	18
		d) Yverdon — Neuchâtel	36
		e) Neuchâtel — Bienne	29
104	...	*Nyon — Crassier-la-Rippe (Frontier)*	6
110	...	*Vallorbe (Frontier) — Vallorbe-station* (P. L. M. trains only)	3
110	...	*Vallorbe-station — Lausanne — Jselle trst.* *	214
		a) Vallorbe-station — Daillens	26
	103*b*.	*b*) Daillens — Renens	15
	101*b*, 102*a*, 103*a*, 130*a*.	*c*) Renens — Lausanne	5
		d) Lausanne — St. Maurice	52
		e) St. Maurice — Brigue	94
		f) Brigue — Jselle trst.	22
111	...	*Le Pont — Vallorbe*	12
112	...	*Vevey — Puidoux — Chexbres*	8

Fig. 36. — Sixth-monthly statement of traffic intensit

e first six months of 1927.

not included)

GENERAL SECRETARIAT.

Statistical section.

rains over the lines of the Swiss Federal Railways.

with à * are electric.

Train-kilometres.	Trains per kilometre of line.	Axle-kilometres.	Axles per kilometre of line.	Gross metric ton-kilometres.	Gross metric tons per kilometre of line.
123 837	8 256	4 093 399	272 893	30 816 141	2 054 409
598 716	9 979	19 652 225	327 537	154 811 581	2 580 193
555 966	10 108	18 535 310	337 006	145 841 034	2 651 655
42 750	8 550	1 116 915	223 383	8 970 550	1 794 110
499 017	4 893	14 643 700	143 566	116 112 694	1 138 360
4 510	902	126 940	25 388	876 895	175 379
100.144	5 007	2 819 372	140 969	22 468 216	1 123 411
209 655	4 461	6 416 076	136 512	51 491 282	1 095 559
184 738	6 158	5 281 312	176 044	41 276 301	1 375 877
599 607	5 821	24 421 516	237 102	192 564 149	1 869 [illegible]55
20 450	4 090	517 000	103 400	4 110 475	822 095
90 049	6 003	3 644 855	242 990	28 558 631	1 903 909
107 900	5 994	4 507 756	250 431	35 497 416	1 972 079
205 231	5 701	8 560 597	237 794	67 316 921	1 869 914
175 977	6 068	7 191 308	247 976	57 080 706	1 968 300
8 670	1 445	63 040	10 507	515 078	85 846
3 264	1 088	44 841	14 947	341 040	113 680
1 304 871	6 098	41 939 738	195 980	353 747 874	1 653 027
124 190	4 777	3 593 620	138 216	31 034 513	1 193 635
74 263	4 951	2 009 668	133 978	17 446 884	1 163 126
31 825	6 365	1 068 020	213 604	8 577 860	1 715 572
418 482	8 048	14 164 977	272 403	116 467 310	2 239 756
548 608	5 836	16 572 003	176 298	140 666 649	1 496 454
107 503	4 886	4 531 450	205 975	39 554 658	1 797 939
17 382	1 449	169 755	14 146	1 212 726	101 060
20 256	2 532	137 554	17 194	1 073 404	134 176

on various lines of the Swiss Federal Railways.

[621 .337]

Irregular vibratory movements of electric locomotives with inclined connecting rods,

By Engineer-Doctor KURT VOSSIUS, Herford.

Figs. 1 to 5, pp. 658 to 664.

(*Elektrische Bahnen*.)

The study of the vibratory movements of electric locomotives is based on the fact that the armature of the motor can be subjected to periodic vibrations superimposed on its principal movement, its rotation, which in turn revolves the axles. In this case the angular velocity of the armature is subjected to periodic variations which are reflected in the running of the locomotive by horizontal vibrations in the direction of travel. The vibrations are made possible by the existence of a large mass (the armatures) and of a part elastically connected thereto (the driving mechanism). It has been observed that their origin is to be found in the play in the bearings, in errors of setting out, and in variations in the yielding of the parts, and that the most critical speeds of the locomotive are those at which one revolution of the driving mechanism corresponds to one, two or four rotative vibrations of the armature (see KUMMER : *Ausgezeichnete Schüttelfrequenzen)*. These vibrations were originally calculated in accordance with the simple theory one was accustomed to use when dealing with harmonic vibrations. But the number of phenomena that could be taken into account when working in this way multiplied indefinitely, and a more careful examination of the nature of the vibrations in question was undertaken. Their duration is greater than that of the harmonic vibrations, which is explained by the formation of the cycle (pseudo-harmonic vibrations) and by the periodically variable constant of damping out (vibrations almost harmonic). The credit for having applied in practice the laws governing these kinds of vibration to the vibrations of the sort we are considering and for having determined in an accurate manner the forms in which these latter are produced is chiefly due to Wichert (1). It was recognised that the best remedy against the irregular jerking movements consisted in increasing the elasticity of the driving mechanism by means of auxiliary springs and by using a suitable damping device. Now the more the elasticity of the driving mechanism is increased, the more the vibrations approach harmonic vibrations, and this is the explanation that to-day as the supplementary springing is used almost everywhere, we can again use with a degree of exactitude allowable in practice, the simple laws for harmonic vibrations, whilst taking into account the increase in the duration of the vibrations by means of an experimentally determined factor varying between narrow limits (2).

(1) A. WICHERT, *Schüttelschwingungen*. Berlin, 1924. Volumes of the « Verein Deutscher Ingenieure ».

(2) See WINKLER, E. u. M. 1924, p. 262. E. T. Z., 1925, p. 326; DÖRY, Vieweg collection, p. 68; KUMMER, *Maschinenlehre*, I, 1925, p. 128.

The arguments set out below will deal with the drive by inclined rods, much used in recent years, which differs in principle from the other systems from the point of view of the generation of the vibrations in question, in that in addition to the causes mentioned above, the drive itself particularly favours the setting up of certain vibrations. This cause is so preponderating that finally, if the usual remedies against the jerking movement are employed, the other causes become quite secondary, so much so that a special examination of this drive from the point of view of the phenomenon of the jerking movements becomes justified.

In Switzerland, quite a large number of locomotives are fitted with inclined connecting rod drive and the German State Railways have at the present time 125 locomotives of this kind in service or in construction, namely those of types C + C (0-6-0 + 0-6-0) and 1B + B1 (2-4-0 + 0-4-2). The movements which arise in spite of the springs and damping devices, as well as the damage to and breakage of driving gear experienced on several locomotives of the 1B + B1 type, resulted in theoretical and experimental research work on an extended scale being carried out in 1926. The opinion that the cause of the rods breaking was defective metal or an isolated excessive strain, was not verified. The metallographical examination shewed on the contrary that the fractures were typical fatigue failures. The fatigue can be produced in two ways : either by prolonged oscillations of the axles or by jerking movements.

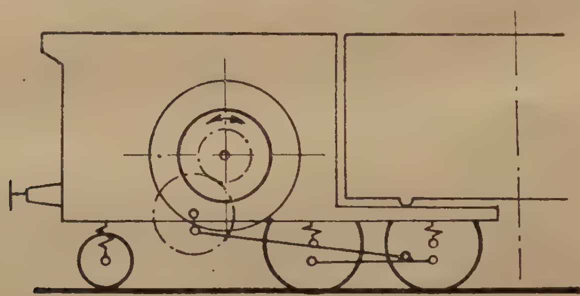


Fig. 1. — Diagram of the drive by connecting rods.

Figure 1 shews that in this system of drive the crank pins of the toothed wheels keyed on to the driven shaft which are in a sense part of the frame, are connected by inclined rods without the use of any jack shaft to the coupling rod pins, that is to say, parts connected to the frame through springs. This drive has considerable advantages : first there is its simplicity; then it makes it possible to develop great power with a small driving wheel diameter, a short length of engine and a moderate weight. Unfortunately, these advantages can only be made use of in the case of goods engines, seeing that this drive, against which, as is known, objections are raised from the kinematic point of view, is not suitable for high speeds. The oscillations of the driving wheels result in the changes of length in the inclined rods pointed out by KLEINOW (1). In practice we take for 10 mm. (0.394 inch) of axle oscillation a change of length of the rod of the order of a millimeter (0.039 inch), but this is of course only true if the upper end of the rod is taken as not changing its position under this effort, which is undoubtedly not the case in view of the elasticity

(1) *Organ für die Fortschritte des Eisenbahnwesens*, 1923, p. 72.

the toothed wheel always has. In reality the thrust is absorbed to a large extent by the springs, and as a result of the kinematic error, the stressing of the rod is notably less than would be inferred from the theoretical changes of length shewn by statical calculations, even if the oscillation of the axle should reach at times a value of 20 to 30 mm. (0.787 inch to 1.181 inch.) Now from this fact, these stresses lose much of the importance ascribed to them at first sight and, from the point of view of the effect thereof, we can at least equal them in the tensions in the rods arising from the jerking vibrations.

On the 2-4-0 + 0-4-2 machines examined, a zone of jerking movements which arose at about 40 km. (25 miles) an hour had revealed its disturbing effect. We began by checking the conditions by calculation starting, for the reasons given above, from the harmonic vibration. The remarkable agreement of the calculated results with the torsiographic measurements effected subsequently supplied the proof that this method of operation is correct. The proper frequency f_e of the rotative vibrations of the armature themselves is given in hertz by the formula :

$$f_e = \frac{1}{2\pi}\sqrt{\frac{1}{\gamma m}}$$

where γ is the co-efficient of elastic flexibility of the drive, that is, of the shafts, springs and rods in $(t^{-1}\ m^{-1})$ and m the moment of inertia of the vibrating mass in (*tm.* per sec²). The critical frequencies of the mechanism are then

$$f = \frac{k}{\mu} f_e$$

in which k is the pre-mentioned factor which takes into account the increase in the true vibration in relation to the duration of the harmonic vibration. It lies between 0.7 and 0.9 for the unsprung driving mechanism : for the gear with stiff springs we are considering, from the conclusions that can be drawn from analogous cases it amounts to about 0.95. For μ it is well to adopt the numbers of the known series of frequencies for the jerking movement, that is to say, of the oscillations per revolution of the mechanism, and in particular the « single figure » numbers 1-2-4. For greater exactitude, it would be necessary to establish the equation for the system of a double pendulum , the two masses of which are the armature and the gear, whilst the elastic parts are represented on the one hand by the driving shaft, the pinion, and the transmission shaft, and on the other by the driving and the coupling rods. These laborious and complicated calculations can be replaced by approximations : we will not go into details on this point. We will simply say that we have found that in the zone of the jerking vibrations existing at about 40 km. (25 miles) an hour a turn of the driving wheels and of the driving mechanism corresponds to a whole rotative vibration of the armature of which the frequency is 2.5 hertz in round numbers. The same result was recorded, as we have said, by the torsiograms measured on some locomotives in service with the Geiger instrument, frequently used for tests of this kind. We can also verify the presence of other single figure zones with 2 and 4 oscillations per turn, but it is extremely surprising that for a single oscillation per turn, the width of the zone and the amplitude are always very much greater than for 2 and 4. As regards the determining causes of the jerking vibrations, we know that with all rod drives 4 and 2 vibrations per turn are due to the play in the brasses and to errors in the lengths and angles of the cranks, and one vibration per turn to errors in the lengths of the rods. It should be noted that the drive in question occupies a special place amongst rod drives : tests have shewn that in spite of the most accurate fitting of the rods, this zone cannot be eliminat-

ed : similarly, it is useless to resort to the method of altering the damping of the elasticity of the gears. It is true that the oscillation of the axles produces each time an alteration of length of the rod. But it is not here that the cause of the particular action of this drive is to be found, as the oscillation itself occurs so irregularly that it is out of the question that it should give rise to a zone of jerking vibrations so characteristic and of so long duration. The play of the bearings, unavoidable owing to the alteration of length, also connot give rise to this single vibration per turn. Quite independent of errors of workmanship, the latter is the result of the characteristic properties of the drive itself and the phenomenon can be explained as follows : the stresses arising in the rods which engender the useful movement of rotation, alternate under the action of a constant moment of rotation in describing a sinusoidal curve with one period per turn of the mechanism. As the rod is connected at one end to the frame and at the other to the axles, which are attached to the frame through springs, the vertical components of the efforts exerted by the rods are transmitted to the springs of the axles, fastened to the frame and impress on the locomotive as a whole vibratory movements in relation to the driving axles about some horizontal axis of vibration parallel to the motor shaft and situated, having regard to the distribution of weight, near to this latter. Corresponding with the number of turns of the mechanism, the frequency of this rocking movement is proportional to the speed of the locomotive. As a rule, it is practically imperceptible, but it increases considerably when its frequency happens to agree with the number, calculated above, of the vibrations proper to the suspended armature. The two movements then find themselves in synchronism, and this rocking movement causes them to reach a high value : the jerking movement of the body of the locomotive can also lead to the armature making rotative vibrations and inversely. This is what in fact occurs at the speed of 40 km. (25 miles) an hour, as practice demonstrates. The horizontal movements of the locomotive caused by the rotative vibration of the armature, as well as the hunting movement of the body of the locomotive, are recorded by the vibrograms, which can also be taken by means of the torsiograph by slightly altering the apparatus. Figure 2 reproduces two of the graphs dealing with the zone of the jerking movements. At the top, we have shewn for comparison, a torsiogram. The vibrograms are naturally much less irregular than the torsiograms. However, in the zone of the jerking vibrations, the movements of the locomotives which are concordant with the turns of the mechanism over-ride all the others, so that the vibrograms have practically the same appearance as the torsiograms.

The preceding considerations only apply at first to one side of the locomotive. The crank pins on the other side are set at 90°, so that under the influence of both sides the body of the locomotive should have a movement rather like that of nosing. Owing to its great mass it tends to simplify its movement and follows the resultant of the two vertical components, at a phase difference of 90° of the efforts developed by the rods. The resultant is at 45° from each of its components. We can find as below the confirmation of these hypotheses in the torsiograms and the vibrograms : of the two lines traced above the principal curve, that at the top indicates the distance on the line travelled over : the distance between two points is equal to one turn of the mechanism. The points were given by a Bosch mechanical lubricator which closed an electric contact each time the gear passed the same place. In this way we can closely determine the co-relationship between the phases of the

rotative vibrations and the position of the driving gear : as a rule, we have been able to observe agreement with the theoretical deductions.

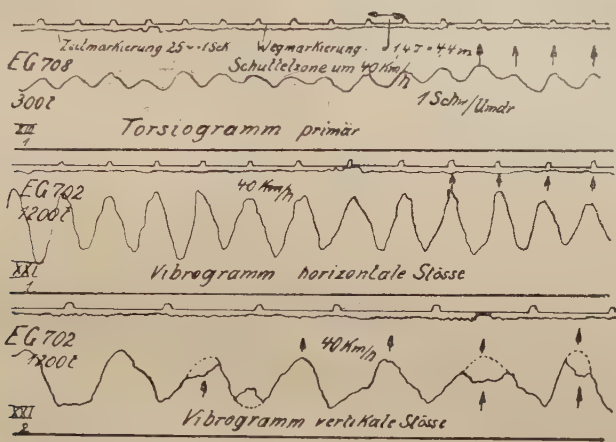


Fig. 2. — Clearly defined zone of jerking vibrations.
Primary torsiogram (rotative vibrations of the motor armature)
and vibrograms (vibrations of the locomotive frame),
vertical and horizontal (in the running direction).

Explanation of German terms : Schüttelzone um 40 km/st. = Jerking vibrations at about 40 km. (25 miles) an hour. — 1 Schw/Umdr. = 1 oscillation per turn. — Stösse = Thrusts. — Wegemarkierung = Distance record. — Zeitmarkierung = Time record.

This generation of the jerking movement with a vibration per turn of the driving gear cannot take place with the other types of rod drive.

The bodies of the locomotives react thereto; also it is true on the rotative vibrations of the armature, and the thrusts of the rods vary therewith also in a sinusoidal form with one period per turn of the driving mechanism, but the link which should unite these two elements is wanting. In fact, the efforts exerted through the rods cannot give rise to any galloping movement of the body of the locomotive because these other drives have always, in conjunction with the inclined rods, jack shafts, so that the two ends of the inclined rods are rigidly connected to the body of the locomotive, whilst the horizontal rods which then form the connection between the body of the locomotive and the axles have no vertical components of the forces.

This mutual rocking movement of the rotative vibrations and of the movements of the locomotive has naturally a marked intensity in the type (fig. 1) of 2-4-0 + 0-4-2 locomotives with units having a single motor and without a rigid frame. With the double motors, for example on the 0-6-0 + 0-6-0 locomotives, a jerking vibration so clearly marked, having one period per turn, can hardly occur, without counting, in this case, because of the small masses of the armature, that the frequencies of the jerking movement, and subsequently the critical speeds of the locomotive would be already outside the limits of the usual working speed.

The recording of the number of turns was so arranged during the tests that the relative position of the crank pins

of the two bogies could be obtained. We have been unable to determine any law that would enable us to say that there exists as between the crank pins of the two bogies any particular positions at which there is a corresponding jerking vibration either particularly strong or weak. The probable reason is the relatively poor continuity of the divided locomotive. If the locomotive had a single frame, the single figure positions would probably exist, and it might then happen that the driving mechanisms through a rocking movement might put themselves into a certain position. This also has not been noted during the tests.

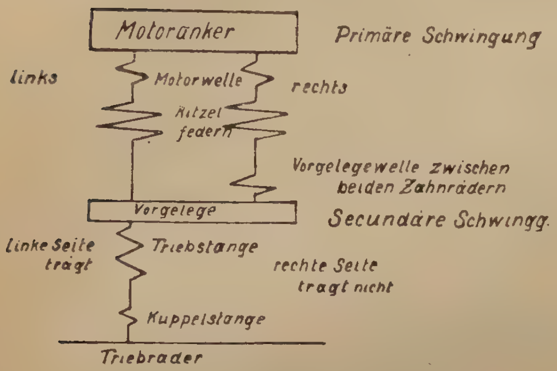


Fig. 3. — System of oscillations.

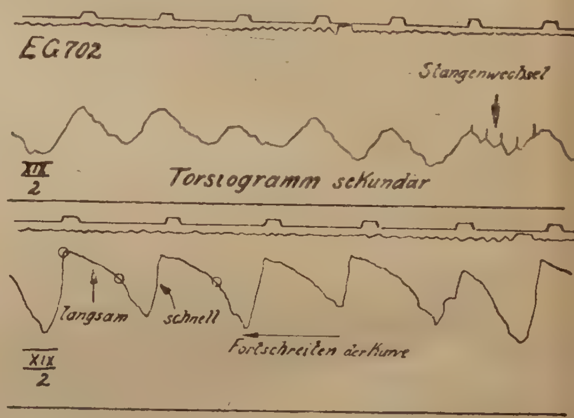


Fig. 4. — Secondary torsiograms (rotative oscillations of counter-shaft.)

Explanation of German terms: Fortschreiten der Kurve = Development of the curve. — Kuppelstange = Coupling rod. — Langsam = Slowly. — Links = Left-hand side. — Linke Seite trägt = Left side bearing. — Motoranker = Armature of the motor. — Motorwelle = Motor shaft. — Rechts = Right side. — Ritzelfedern = Pinion springs. — Rechte Seite trägt nicht = Right side does not carry. — Schwingung = Vibration. — Schnell = Quickly. — Stangenwechsel = Alternation of the rod. — Triebräder = Driving wheels. — Triebstange = Driving rod. — Vorgelege = Transmission. — Vorgelegewelle zwischen beiden Zahnrädern = Counter-shaft between two gear wheels.

The torsiograms have been recorded, not only from the shaft of the armature, but also on the toothed ring of the pinion connected to the shaft by springs. Figure 3 shews the layout : a drawing of this kind is very convenient when calculating the total elasticity from partial elasticities arranged in parallel and in series, seeing that the elasticities can be treated as the conductivities in electric insulations. To make a distinction between them, we shall call *primaries* the torsiograms of the armature (that is to say, the first mass of the double pendulum) and *secondaries* those of the driving gear. The primary oscillations are, under the softening action of the springs of the pinion, very approximately harmonics, whilst in the secondary oscillations all the thrusts of the connecting rods appear with the other movements. During one revolution of the driving gear, there is reversal of vibration in the carrying rods four times (fig. 4) as the upper secondary torsiogram clearly shews. In the secondary torsiograms, the form of the curves is most often angular and has the typical appearance of the lower torsiogram in the photograph. As the torsiograms are read from right to left, this form means that after a slow progression from rest to the maximum point, the part in oscillation is suddenly reversed. This fact can be explained by the action of the absorber which tends to damp out the vibration, but

which never succeeds in doing so in this present case, because the drive again comes into action and causes the parts to rotate. The inertia of the torsiograph prevents us from following the forms of curves relating to still more delicate actions : for this it would be necessary to use much more sensitive instruments. For practical purposes, however, the methods described above are amply sufficient.

The remedy against the disturbing vibrations having one period per revolution of the driving mechanism cannot, we repeat, be found either in the exact fitting of the rods and the suppression of play in the bearings, or in any alteration to the damping devices. The nature of the drive is such as not to permit of these vibrations being eliminated, but they can be transferred to a zone of speeds outside the limits of normal running at which they are harmless.

In the existing machines, only the elasticity is altered, namely that of the pinion springs, which play a preponderating part in the whole of the elastic part of the driving gear. As the frequency is proportional to the square root of the elasticity, to get an appreciable displacement of the zone of the jerking movements it is necessary to modify the suspension very considerably, and in this respect it is principally constructional difficulties which fix the limits. Taking into account the width of the zone and of the variable factor $k = \frac{f}{f_r}$, we find that for the 2-4-0 + 0-4-2 locomotives, the raising of the speed from 40 to 80 km. (25 to 50 miles) an hour — up to 65 km. (40 miles) an hour, we should be quite outside the zone of one vibration per turn — would make it necessary to do away with the auxiliary spring of the pinion entirely. But in this case it is to be feared that the zones with $\mu = 2$ and 4, which correspond to 40 and 20 km. (25 and 12 1/2 miles) an hour would reappear with their disturbing effects : so that there is no possibility of remedying it by the spring gear and damping devices. Furthermore, it is most undesirable to suppress the spring gear because, as we have seen above, the thrust, due to the oscillations of the axles and absorbed to a large extent by the springs, would then be transmitted as a whole. There then only remains the opposite method, that is to say, the lowering of the critical speed by the use of softer springing. The method has in fact been used with success on these machines. The critical speed has been fixed at about 25 km. (15 miles) an hour : consequently the dangerous zone is soon passed through during the starting period in the same way as with steam turbines, with which the critical number of turns is sufficiently lower than that corresponding to the working speed.

We will now consider yet another possible cause of vibrations when using this drive. In the 2-4-0 + 0-4-2 locomotives, the number of the vibrations of the body of the locomotive itself in ratio to its axles, in the vertical sense is, in round numbers, 5 hertz, or exactly double the frequency of the rotative vibrations proper to the armature with the original springing. These rotative vibrations give rise to, in the zone of one vibration per revolution, during a half turn, an advance and during the next halfturn a retardation of the crank pins in relation to the uniform rotation. Let us suppose, for example (fig. 5) that the positions of the crank pins moving with a uniform motion, namely A_1 B_1 C_1 D_1 on the driven shaft V become A_2 to D_2 on the driving wheel T, but that as a result of the rotative vibrations, the crank pins on the driven shaft do not come at the instants considered at B_1 and D_1, but instead at B'_1 and D'_1. The result is that the rod is stressed during a revolution twice in the same sense by the rotative vibration : in the example chosen it is under compression both times whilst at A and C it is not stressed at all. The frequency

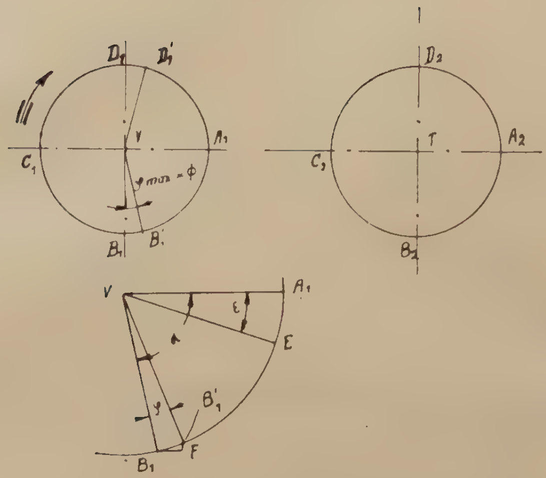


Fig. 5. — Position of the crank pins.

Explanation : V = Jack shaft. — T = Driving axle. — V = Movement in the direction of the arrow. S = Angle of advance.

with which the rods are stressed is therefore in this case double that of the rotative vibrations causing it and, in consequence, coincides in this zone with the frequency proper to the springing of the axles. Analytically we find that if not exactly A, but E, is taken as the origin of the vibrations

($\sphericalangle$ EVA $= \varepsilon$) :

$$B_1VB'_1 = \varphi = \Phi \sin(\omega t - \varepsilon).$$

Alteration of length of the rod :

$$B_1F = \Lambda = \Phi \sin(\omega t - \varepsilon).\ \sin \omega t =$$

$$\Phi\left(\sin^2 \omega t \cos \varepsilon - \frac{\sin 2\omega t}{2} \sin \varepsilon\right).$$

We get, for example, as the resultant of the two driving sides for :

$$\varepsilon_1 = \pm 45^{\circ} \text{ and } \varepsilon_2 = -45^{\circ},$$

$$\Lambda = \Phi \cdot 2 \sin 45^{\circ} \cdot \sin^2 \omega t,$$

that is to say, an oscillation of the frequency 2 wt = about 5 hertz at the speed of 40 km. (25 miles) an hour. However, the drive allows the chassis to give, in relation to the axles, and from this fact the body of the locomotive starts to oscillate in the vertical plane with its own frequency (5 hertz) depending upon the springing of the axles. Inversely, this naturally brings a fresh reinforcement of the rotative vibrations. In the vibrogram, this phenomenon reveals itself by the hooks in the main curve (fig. 2). Here again the position of the phases can be located with every certainty. The springing of the axles concording with the supplementary stressing of the rods is fortuitous, but shews the care required with this drive. The remedy is not difficult in this case : any modification of the springs of the pinion alters the frequency of the rotative vibrations, whilst the springing of the axles remains unchanged, which results in the two vibrations being out of phase one with the other. The previously mentioned lowering of the critical speed thus eliminates at the same time the second possible cause of disturbance: this has also been noted in service.

To sum up, we can say of the causes of the vibrations produced when using the rod drive, that in this case, the body of the locomotive is subjected to,

under the action of the vertical components of the forces acting on the rods, oscillations which in the zone of resonance with the rotative vibrations of the armature, can be expected to result in a jerking or snatching movement. This phenomenon is due to two causes, independent one of the other.

In the first place, the movements which are set up by the thrusts of the rods transmit the ro ary movement and cause the body of the locomotive to rotate with a frequency proportional to the running speed. At the critical speed this frequency equals the actual frequency of the rotative vibrations of the armature.

In the second place, the oscillations which are set up by the additional stresses produced in the rods by the rotative vibrations of the armature, and which cause the body of the locomotive to oscillate at a frequency double that of these rotative vibrations. At the corresponding critical speed, this frequency is the same as the particular frequency of the body of the locomotive in relation to its axles, depending upon the springing of these latter. A particularly unfavourable case is that which occurred by chance with the 2-4-0 + 0-4-2 locomotives before the springing of the pinion was modified : it is the case in which the critical speeds are the same for the two causes setting them up.

In order to be certain of not suffering from this snatching movement, it is therefore not enough to fit the driving mechanism with springs and damping devices capable of absorbing the efforts transmitted, but it is essential that the springing be so arranged that the *unavoidable* zone of one oscillation per turn be favourably situated, and be therefore, as far as possible, brought below the range of working speeds so as to render it practically unobjectionable. We can then take advantage of the incontestable merits of this drive, and the locomotives which are so fitted will give in service excellent results.

[621 .138.5 (42) & 725 .35 (.42)]

The reorganisation of Crewe locomotive works, (1)

(*Paper and discussion*)

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Figs. 1 to 11, pp. 667 to 676.

(*Engineering.*)

Crewe Works were established in 1843, for the purpose of repairing the locomotive stock of the Grand Junction Railway. The works originally covered 2 1/2 to 3 acres; the number of men employed was 161, and the stock of the company was 75 engines. As in the lay-out of many old works in this country, insufficient attention was paid to the possibilities of future expansion, housing accommodation

(1) Paper read before the Institution of Mechanical Engineers, on 16 March 1928.

for the staff being built in immediate proximity to the shops in which they worked. This, coupled with the fact that the site chosen was in a triangle bounded on the north side by the Liverpool line and on the south by the Crewe and Chester line, left only one direction in which the works could be extended. Figure 1 shows the extent to which the works had grown at the termination of the war.

In early days, the locomotive stock consisted mainly of six-wheeled engines. The introduction of eight-, ten-, and twelve-wheeled engines between 1900 and 1920, together with the increase of stock to upwards of 3 400, increased the work of manufacture and repair to the following extent : The tonnage (including engine and tender when empty) increased by 72 792 tons, whilst the length of the engine stock, from buffer to footplate, increased by almost 6 miles. The increase is shown graphically and in detail in figure 2.

Owing to this growth and the fact that the old erecting shops were incapable of being altered to suit modern requirements, in consequence of height, width, and other structural considerations, the want of suitable accommodation began to be acutely felt in 1913, and the extension of No. 9 erecting shop and the fitting shop was authorised. The war, however, interfered with the continuance of the programme, and it was not until 1919 that it was possible to continue the reorganisation of Crewe Works, the need being increased by the introduction of the 47-hour week. In this year, the construction of a complete new erecting shop was commenced alongside No. 9 erecting shop, but this was stopped at a later date. In 1921, the necessity of continuing the reorganisation became pressing, and a start was made on the re-equipment of the machine shop with modern machine-tools, the extension of the wheel shop, and the removal of the smithy from the old works, to the steel works, the old works being shut down and the work concentrated at the steel works end. At the same time it was decided to obtain what electrical power was required from the North Wales Power Supply Company; this enabled the three power stations within Crewe Works to be closed.

In 1922, the lay-out of the new Siemens-Martin steel furnaces was designed and in 1924 it was decided to finish the reorganisation by the completion of the partially-built erecting shop and its extension, so as to enable No. 9 shop and the new building to be formed eventually into one shop. The new shop would then accommodate the whole of the engines in the works for repairs. It was further decided to provide better siding facilities inside the works, to utilise the old erecting shops for the purposes for which they were most suitable, to cut down transport to a minimum, and to construct a new boiler-building establishment at the old works, capable, if necessary, of manufacturing all the boilers required for the London, Midland and Scottish Railway. Reference to figure 3, will show that in this lay-out the old brick yard was demolished, the high ground on which it stood being removed so as to give the necessary siding accommodation shown in figure 4. This reorganisation affected the signal shop, tin shop, galvanising plant, joiners' shop, millwrights' shop, testing shop, wheel shop, tender shop, tube shop, smithy, iron foundry and machine shop, modern machines being installed where necessary.

In the lay-out of the reorganised works, the use of the shops was rearranged so as to eliminate transport wherever possible, and the machines were installed so as to permit the manufacture and repair of component parts to progress process by process. For instance, the whole of the new boiler-building plant is now accommodated in the old works; each individual boiler plate from the plate stores proceeds down the length of the shop as

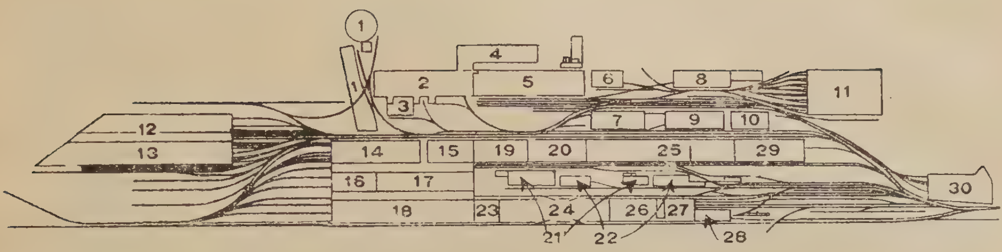

Fig. 1.

1. Brick making mill.
2. Iron foundry.
3. Chair foundry.
4. Pattern shop and stores.
5. Tender shop.
6. Brass foundry.
7. Copper and tube shop.
8. Signal shop.
9. Wheel shop.
10. Nut and bolt shop.
11. Paint shop.
12. Machine shop.
13. No. 9 erecting shop.
14. No. 8 erecting shop.
15. Boiler mounting shop.
16. Plate stores.
17. Flanging shop and smithy.
18. Boiler shop.
19. No. 6 erecting shop.
20. No. 5 erecting shop.
21. Power and boiler houses.
22. Gas producers
23. Points and crossings shop.
24. Rail mill.
25. Forge.
26. 20-ton furnaces.
27. Spring mill.
28. 30-ton furnaces.
29. Steel foundry.
30. Stoneyard.

Fig. 2. — Increase in locomotive stock and details, 1900-1920.

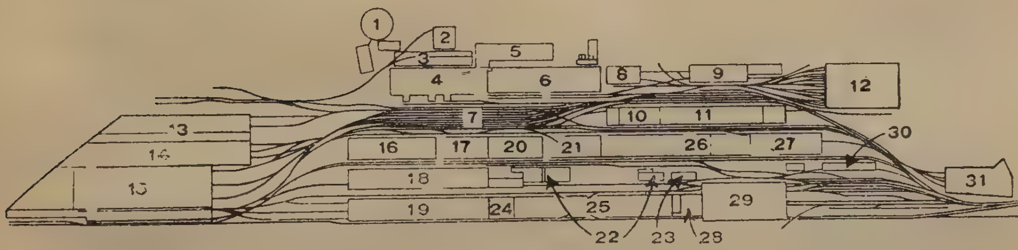

Fig. 3.

1. Brick-making mill.
2. Chair foundry.
3. 6-ton gantry.
4. Iron foundry.
5. Pattern shop and stores.
6. Tender shop.
7. Engine storage roads.
8. Brass foundry.
9. Brass finishing shop.
10. Copper shop.
11. Wheel shop.
12. Paint shop.
13. Machine shop.
14. No. 9 erecting shop.
15. New erecting shop.
16. Finished part stores and welders' shop.
17. Mounting shop.
18. Smithy.
19. Boiler repair shop.
20. Tube shop.
21. Heavy machine shop.
22. Power and boiler houses.
23. Gas producers.
24. Points and crossings shop.
25. Rail mill.
26. Forge.
27. Steel foundry.
28. Spring mill.
29. New melting furnaces.
30. Ingot-stacking gantry.
31. Stoneyard.

each successive operation is performed, and it is eventually delivered to the riveting machines at the west end of the building, flanged and machined ready for assembling. The whole of the work is performed by modern high-power machines. The actual building of the boiler also progresses in the same way, the men being kept in one position and the boiler moving from stage to stage.

Heavy machine shop. — No. 5 erecting shop, which adjoins the forge at its western end, has been converted into a heavy machine shop, in which frames, hornblocks, cylinders, footplates, etc., are machined and assembled complete. The rolled frame plates now pass immediately from the rolls at the west end of the forge to the slotting machines at the east end of the heavy machine shop, the latter being laid out so that work progresses in a westerly direction, eventually leaving as a completely assembled frame *en route* to the erecting shop by road on the south or north side of the shop as may be found most convenient. The most notable machines in the heavy machine shop are a plano cylinder-milling machine and a horizontal cylinder-drilling, boring, tapping, and milling machine.

Engine-erecting frames. — These consist of three machines, each capable of taking the longest locomotive. Sunk in the floor of the shop are long, accurately machined, cast-iron girders (fig. 5), on which sliding supports for the frames can be fixed at the exact centres corresponding to the type of engine being built. The frames, with horns complete, are dropped on to these supports. The supports centralise the horns, thus ensuring that the frames are square and at the correct height with regard to one another. They also give the exact position for fixing cylinders, motion-plate, footplates, etc. These have only to be dropped in place between the frames and bolted up, and once the machine is set up, locomotives exactly similar, so far as centres are concerned, can be erected without the aid of wires, trammels, etc. As most of the machine tools in the shops are independently motor-driven, little shafting exists, but where shafting has been installed it is fitted throughout with ball bearings.

Machine shop. — The work of the machine shop, which previously included both production and repairs of all components, was divided up. Brass work was removed to the old signal shop, close to the brass foundry, and heavy machine work, such as that in connection with frames, hornblocks, cylinders and footplates, was concentrated, as has been stated, in what was previously No. 5 erecting shop. The machine shop itself now consists of two bays, each 42 feet wide by 660 feet long, and an arcade 40 feet by 740 feet long, equal to an area of 85 000 square feet, and contains the combined plant from the old works and the steel works, comprising 422 machines. Shaping and planing operations have been superseded by milling, and pins, shafts, and various bearings, which were previously finished by turning, are now ground to fine limits on modern machines. The limit system is on the « unilateral » principle, with the hole as a base, a plus allowance on the standard, and a minus allowance on the shaft. A standardised supply of limit-gauges is available.

Before the present reorganisation, each section was arranged so that the machinery dealing with the various sectional parts was grouped close to the benches where they were stripped and assembled. Congestion was, however, so great as to interfere with the transport and progress of the work.

New and complete plant for the manufacture of pistons and all bar work has been installed, and in this department is also situated the tool room in which the tools are not only repaired and ground, but all the large twist drills, taps,

Fig. 4. — Yard for stabling engines.

Fig. 5. — Frame jig with frame plates.

cutters, reamers, gauges, etc., used in the works are manufactured. A total of 121 new machines has been installed in this shop, consisting of turret and capstan lathes, shaping and slotting machines, drills, and milling and grinding machines, by all the best-known machine-tool makers. Economical use of high-speed steels is made by providing carbon-steel tools with tips of high-speed steel of minimum size. A further aid to output is the adoption of a standard tool shape, ground from the solid on oscillating tool grinders; this eliminates the forging of tool shapes. Group driving is arranged where it is economical, having always in view the desirability of standardising motors.

No. 9 erecting shop. — Adjoining the machine shop is No. 9 erecting shop, which consists of two bays (north and south), 803 feet, and 882 feet long respectively, and each 45 feet wide, with a machine bay between them. Six 40-ton, one 6-ton, and one 4-ton electric overhead cranes serve this shop.

Prior to the reorganisation all the heaviest locomotives coming into Crewe Works had to be repaired in this shop. The method of approach was by lines from the east end and a traverser about two-thirds of the way down the shop. It is now possible to utilise the south bay of this shop for light boiler repairs, and thus avoid transferring boilers from the erecting shop to the boiler repair shop.

New erecting shop. — A new erecting shop has been constructed immediately adjoining No. 9 shop, as shown in figure 3; a cross-section of this shop and the new machine shop is shown in figure 6, and a photograph in figure 7. It will be observed that it consists of three erecting bays, each 642 feet long and 63 feet wide. Each bay is provided with two pits and a central road. Spanning these pits are two 50-ton, 4-motor, overhead cranes, particulars of which are as follows :

	Speed, feet per minute.	Motor, horse-power.
Hoist	6	30
Auxiliary hoist . . .	20	12
Cross travel	80	12
Longitudinal travel .	200	30

There are also three 10-ton, 3-motor, overhead cranes, with an additional crane in the south bay to deal with wheels, which have the following speeds and power :

	Speed, feet per minute.	Motor, horse-power.
Hoist	20	20
Cross travel	100	3
Longitudinal travel .	350	16

The motors are of the alternating-current, slip-ring type, 416 volts, 3-phase, 50 cycles frequency. It will be noticed that the high-speed light cranes are run at a lower level than the heavy overhead cranes, for, as a result of the increase in size of engines, many parts that were previously lifted by hand are now of such weight as to necessitate mechanical assistance. The whole of the pits have been constructed of ferro-concrete.

The framework of the shop is a steel structure, forming a complete unit, and is designed to withstand the loads and wind pressure on the building. The south, east and west gable walls are of brick, and take no portion of the working loads of the shop. The floor is constructed of wood blocks on edge, and concrete paths for electric trucks are provided where necessary. The roof is of glass, and all astragals, etc., are lead covered. Some criticism was raised to the effect that the shop would be unduly hot during the summer. Records taken in 1926 show that there were only nine occasions during the year when the temperature reached 80° F. The heating of the shop is by means of steam, and is of the overhead type. The system is split up into twelve sets of pipes, each

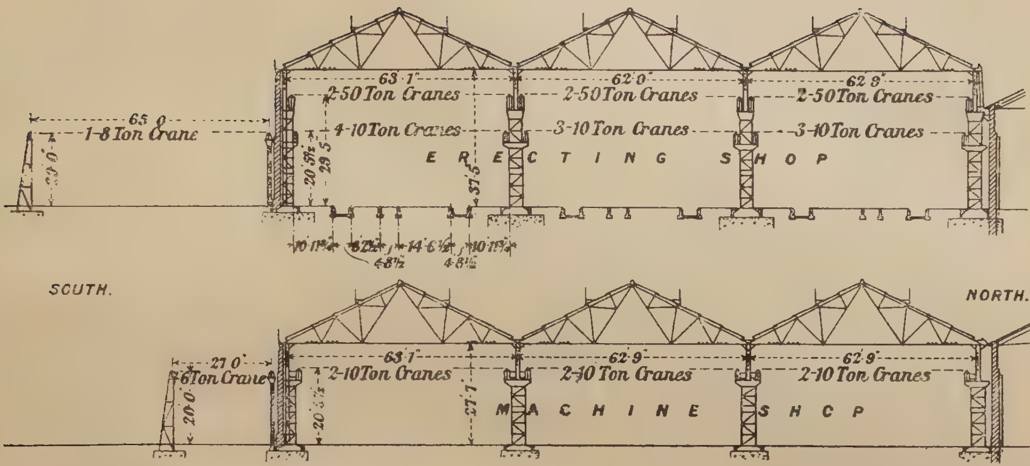

Fig. 6. — Cross section of new erecting shop and machine shop.

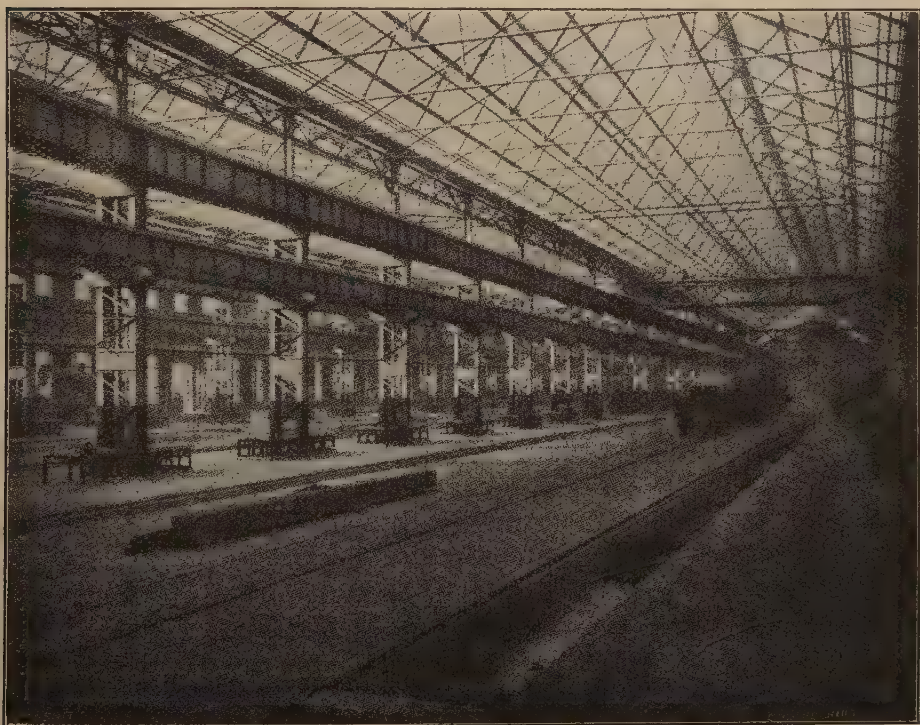

Fig. 7. — New erecting shop.

set consisting of one steam-flow pipe and two return pipes. Two sets are located on either side of each erecting-shop and machine-shop bay, and are placed above the bottom tie of the roof principal. The condensate is returned to the boiler as feed-water. The whole of the system is divided into four main portions for the purpose of providing efficient circulation, main steam supplies being taken at three points. With this system it has been found possible to maintain an inside temperature of 55° F. when the temperature outside is at freezing point. Four water-tube boilers are installed, three working and one standby. These, in addition to supplying steam for heating the new erecting shop, also provide for the heating of No. 9 erecting shop, the machine shop and all boshes.

The shop is electrically lighted by alternating current at 416 volts. Main lights are placed overhead at both sides of each bay, and under the 10-ton craneway. Plugs are provided immediately above the fitters' benches for driving portable machine-tools and for providing auxiliary lighting.

At the west end, the traverser-table working into No. 9 shop is able to traverse the whole of the new erecting shop on the southern side. On either side of this traverser eighteen pits allocated solely to the stripping of engines have been constructed, whilst immediately adjoining are installed mechanically-operated boshes for cleaning the stripped parts. Reference to figure 3 will show a triangular portion at the west end of the shop which is devoted to re-conditioning those portions of the locomotive not requiring transport to the machine or wheel shop. A cross-section is shown in the lower half of figure 6. The capacity of the shop is 66 engines, taking the engine length plus an allowance for a gap between each engine at 42 1/2 feet, and the output from the shop is equal to 30 to 35 heavy repairs per week and 100 new locomotives per annum.

Before coming to a decision as to the design of this shop, very careful consideration was given to the claims in support of longitudinal as against cross pits, and the probability of the future reconstruction of No. 9 shop was also taken into account. As will be seen from figure 3, it will be possible at a future date to reconstruct it so as to form a portion of the large shop.

Processing repairs of locomotives. — The method of processing the repair of locomotives is representative of the principle, now employed throughout the works, of moving the work to the man rather than the man to the work. The locomotive is moved down the shop in eight successive stages. At each stage the appropriate components are added by men expert in their particular work, and the duration of the working time in each stage is regulated to 7 hours 50 minutes. By this means an engine is stripped and given a heavy repair in 12 days, as compared with 30 to 40 days generally occupied on such work. The complete progress of the work is illustrated in figure 8. An engine requiring a heavy repair is brought into the erecting shop over the traverser at the west end of the shop, and is placed on one of two positions immediately adjoining the traverser. It is here stripped of its wheels, motion, boiler, and all other parts requiring repairs, this occupying two working days, during which the parts for repair are distributed to the appropriate shops. The staff engaged on stripping the engines are confined to this work, and as two engines are stripped simultaneously, there is an output of one stripped engine per day.

On completion of stripping, one engine frame daily is placed on its stand on one of the four adjoining positions in the pit, these positions being numbered stages 1, 2, 3 and 4. The gangs, of which there are four, move between stages 1, 2, 3 and 4 as they finish their own particular work

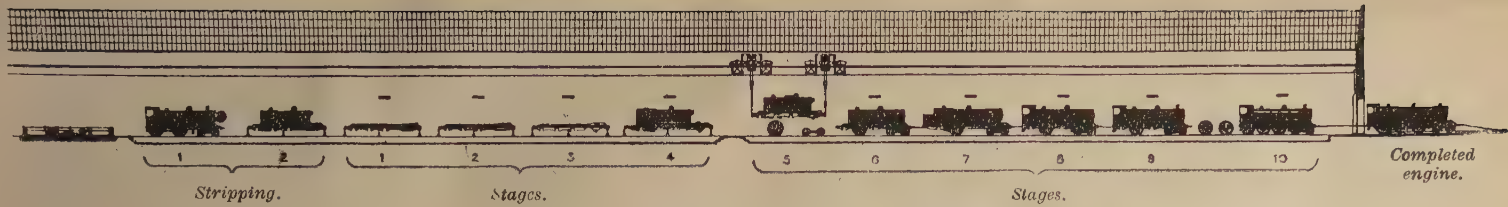

Fig. 8. — Processing of repairs to locomotives.

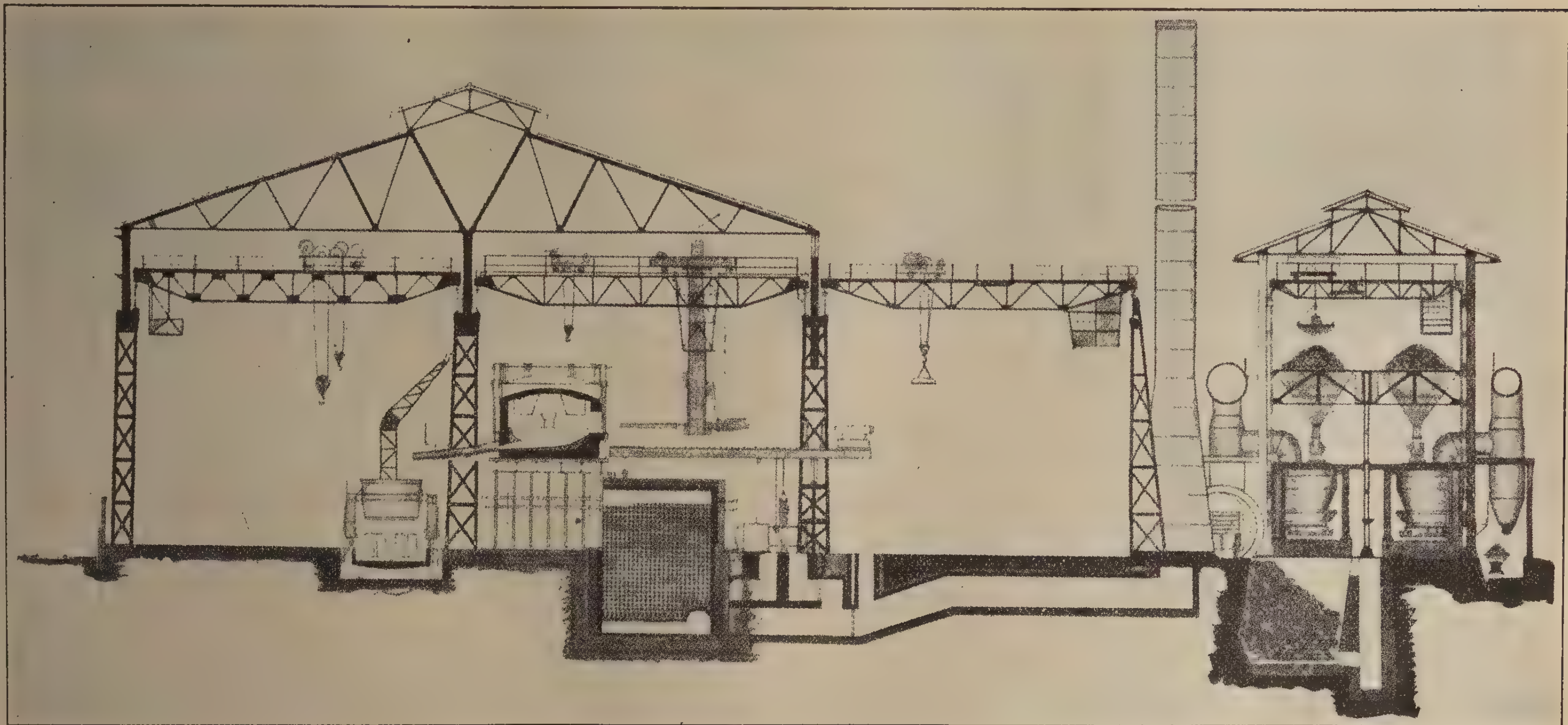

Fig. 9. — Cross section of steel-making plant.

at a stage. Four working days are allowed for an engine frame to remain on its stand. On the fifth day, the intermediate and truck wheels have been returned repaired, ready for the frame and boiler from one of the first four stages, to be lifted on to the wheels. In stages 1, 2, 3, 4 and 5, the following work is carried out :

Stage 1. — Cleaning tops of cylinders, ends and covers; examination of frames and cylinders. Removing steam-chest liners; drilling studs, set-screws, etc., on cylinders and frames, and welding any cracks. Welding frames; replacing dragbox; boring cylinder; fitting studs.

Stage 2. — (Fitting steam-chest liners); refitting pivot casting; (chipping and grinding frames after welding). Boring steam-chest liners; replacing hornblock patches. Remaking back cylinder-cover joints.

Stage 3. — Setting slide-bars; fitting hornblock keeps; straightening front end. Setting radius-rod brackets; fitting studs for guide brackets; filing hornblocks. Mounting boiler in frame and bolting up.

Stage 4. — Fitting 3 1/2-inch exhaust pipe brackets wash-out plugs, and blow-off cock; mounting whistle stand. Mounting cylinder cocks and gear, intermediate oil pipes, safety-valve and fitting crossheads. Fitting pistons and rings, cylinder covers and packing. Lagging ashpan and fitting damper doors.

Stage 5. — Adding radial truck and intermediate wheels under engine. Mounting vacuum sack and brackets, buffer plank, drawbar hook, brake guide or rocking-shaft brackets, piston-valves, damper gear and part of lubricator gear.

Thereafter the locomotive is hauled down the shop to stages 6, 7, 8, 9 and 10, moving one stage per day. Each day the following work is carried out :

Stage 6. — Mounting buffers, stiffening plates, lamp brackets, snifting valves, and air-pump. Fitting panels, expansion brackets, dirt plates, reversing-screw and rods, reversing-shaft quadrants, etc., and rocking gear.

Stage 7. — Carrying out part of smokebox work, mounting steam-pipes and bolting up smokebox. Mounting injector and cab, locking gear, sand gear and lubrication to axleboxes. Refitting splashers, sand boxes and footsteps.

Stage 8. — Completing smokebox work; finishing cab and footplate; fitting 3 1/2-inch exhaust pipe. Mounting mechanical or Detroit lubricator and pumping oil through.

Stage 9. — Mounting wheels and setting in position. Fitting up motion and connecting-rods. Wheeling engines, bolting up hornblock keeps, stays, centre-bearing wedges and cap. Fitting radial truck pivot studs and nuts, cylinder-cock pipes and brackets, oil pipes and brackets.

Stage 10. — Fitting up brake-work, coupling-rods, crank-pin washers, sand pipes and stays. Assisting valve setters. Fitting steam-chest covers, covering plates and door. Adjusting weight and lifting engine off pit.

On the twelfth day (allowing two days for stripping) the engine is hauled out of the shop completely repaired. Such a method of repairing engines enables various appliances to be used for facilitating the erection of components, which are always kept in the same place, instead of having to be carried about the shop, such as a screw-jack for the erection of the vacuum sack and bogie pivot casting, staging for riveters working on the smokebox, and appliances for lifting connecting and coupling-rods.

When this system was first brought into operation, the engines were hauled down the shop by means of an overhead crane working round a snatch-block sunk into the floor of the pit, each engine being attached to the next by a wire cable. Two electric winches placed out-

side the erecting shop have now superseded the overhead cranes, and in consequence the loss of time for lifting has been reduced. In the first instance this system of repair was concentrated on one type of six-coupled express passenger engine. Development of the system, however, has made it possible to have as many as five different classes of engines on what is locally known as « the belt » at one time, this alone being made possible by the fact that the repairs to boilers, tanks, panels, splashers, cabs, injectors, ejectors, drivers' valves, vacuum sacks, axleboxes, tubes, bogies and superheater elements are all processed in this way, the processing of the locomotive itself being the final and spectacular result of the system generally. Obviously it is necessary to have certain spare parts available before such a system can operate. Experience shows that at least two sets of spare wheels, two pairs of cylinders, four sets of axles, and ten crank-pins per class of engine repaired, and 6 % of spare boilers, together with the various nuts and bolts, should be accumulated before attempting to work to this system.

There are now in operation four belts, dealing with 17 different classes of engines, each belt of 12 engines giving an output of one engine per day throughout the working week. Since the first engine was turned out by this system on 5 May 1927, over 776 engines have been repaired without any delay whatever. It should be mentioned that the pre-arranged times of movement are most strictly worked to, a clock which is altered daily showing the time for the move the next day. A move is made on the blowing of a buzzer in the shop. This time limit is one of the most important features of such a scheme. The knowledge that component parts must be delivered in time to be put in before the next move proves a powerful incentive to every shop in the works.

Tenders are now being repaired in the tender shop on much the same principle, the time taken for a heavy repair being four days as against eight to nine days under the old method. The wheel stacking ground on the south side of the shop is equipped with a 6-ton, 3-motor, overhead crane with gantry 364 feet long and 27 feet span. The following are the particulars :

	Speed, feet per minute.	Motor, horse-power
Hoist	20	12
Cross travel	80	3
Longitudinal travel .	350	12

Adjoining this is the stacking ground where all cabs, panels, splashers, and other material not immediately requiring repairs are stored. Spanning this ground are two 8-ton, 3-motor, overhead cranes with gantry 588 feet long and 65 feet span, of which the following are the particulars :

	Speed, feet per minute.	Motor, horse-power.
Hoist	20	16
Cross travel	100	3
Longitudinal travel .	350	16

Motors are of the slip-ring, alternating-current type, 416 volts, three-phase, 50 cycles.

Boiler repair shop. — This has now been converted into purely a repair shop for boilers coming from the erecting shop. Access to any bay of this shop can be obtained from any bay of the erecting shop via the traverser without crossing other roads, as was formerly the case. Such repairs as the provision of new fireboxes and new wrapper plates can be carried out here with materials supplied from the new boiler-building establishment. On completion of the repairs, boilers pass to the boiler-mounting and testing shop and then back to the erecting shop. In re-arranging this shop the opportunity has been taken of processing the work.

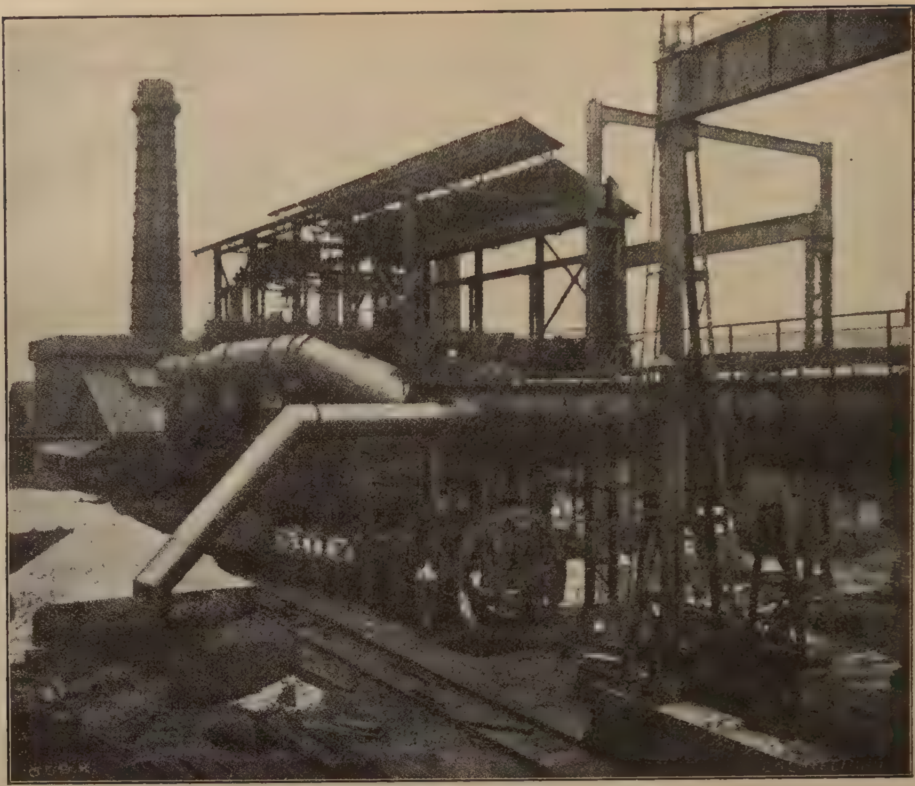

Fig. 10. — Gas machines.

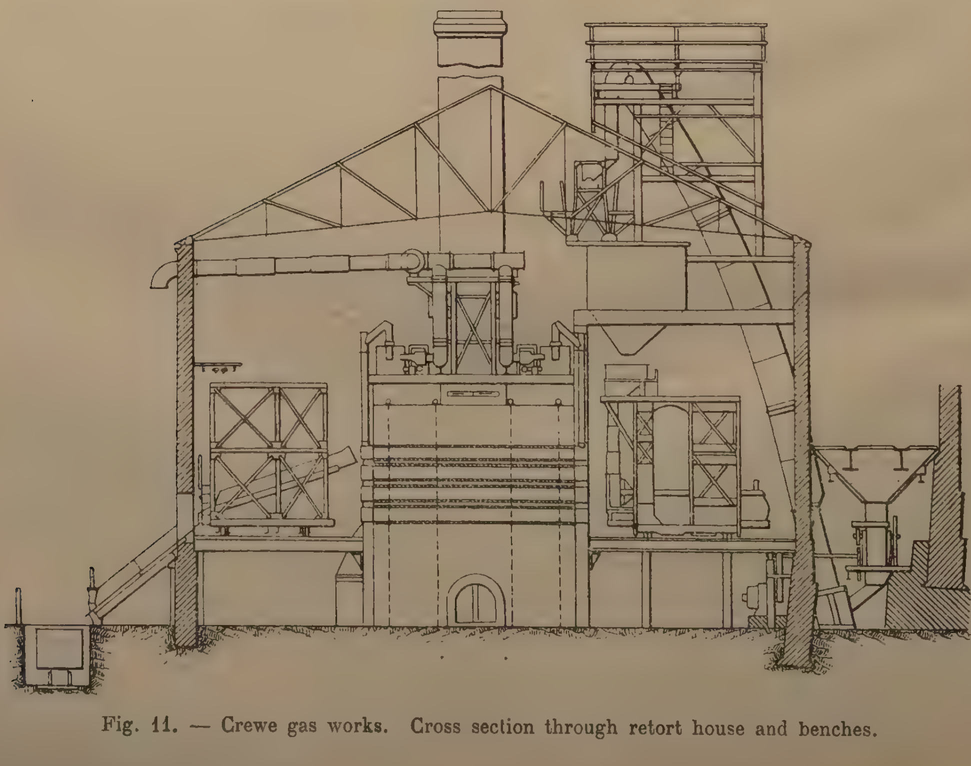

Fig. 11. — Crewe gas works. Cross section through retort house and benches.

Steel works. — Since 1864, steel has been manufactured at Crewe. In 1923, the plant consisted of seven 20-ton and three 30-ton hand-charged furnaces heated by 64 small hand-fired water-bottom, steam-blown « Wilson » type producers. In November 1923, it was decided to modernise the whole plant. The new lay-out consists of two 40-ton to 45-ton acid openhearth furnaces, and two 60-ton to 70-ton basic openhearth furnaces, with an estimated yearly output of 84 840 tons of ingots. A cross-section of the new steel-making plant is shown in figure 9.

An open stockyard, 400 feet by 53 ft. 9 in., is served by two 10-ton overhead electrically operated cranes, each fitted with a 5-ton lifting magnet. Three wagon-roads pass through and accommodate all the wagons containing the raw material required.

The furnace bay is 400 feet by 59 ft. 6 in., giving a working space in front of the furnaces varying from 34 feet to 37 ft. 6 in. The furnaces are of the most modern type. The gas and air out-takes from the slag chambers are built up separately with air circulation all round, thus preventing the possibility of mixing and consequent destruction of the brickwork. The regenerators are placed well away from the furnaces. The furnaces hearth is carried quite clear and independently of the slag pocket area, and the entire hearth and port ends are joined up in a strong independent framework carried on the furnace bottom joists.

The hearth of the acid furnace at foreplate level is 11 feet wide by 28 feet long, giving an area of 308 square feet, or 7.7 square feet per ton of furnace capacity. The hearth of the basic furnace at fore-plate level is 14 feet wide by 36 feet long, giving an area of 504 square feet, or 8.4 square feet per ton of furnace capacity. The regenerators are capacious; in the acid furnace they contain 10.1 cubic feet per square foot of hearth area, and in the basic furnace 10.7 cubic feet per square foot of hearth area.

Gas machines. — The 64 old hand-fired gas producers have been replaced by six mechanical gas machines (fig. 10). They are designed to gasify all the coal required to operate the new melting furnaces and, in addition, supply the forge and rolling mills and the reheating furnaces with the necessary gas.

Gas works. — Gas for the illumination of town and company's property has been manufactured on the present site since 1884. The capacity of the plant (1 239 000 cubic feet per day) being taxed to its utmost, it became necessary to rebuild and enlarge the station. This has now been carried out by the erection of a new mechanically operated installation of horizontal retorts, with water-gas plant, waste-heat boiler, condensing towers, wet purification and dry purification plants, and the provision of a 1 million-cubic foot holder (fig. 11).

The results obtained from the reorganisation may be summarised thus : Reduction of transport costs; decreased manufacturing costs of steel, locomotive boiler, and all components; increased output of repairs and renewals with decrease in overtime and nightshift working; decreased time of locomotives out of traffic, and consequently less stock of locomotives required; reduction in quantity of portable tools and in labour costs; lower supervision costs in erecting shop; decreased cost of electric current and of gas; and finally, the reorganisation enables Crewe to cope with the increased size of locomotives and the additional requirements due to the grouping of the railways.

This paper gave rise to the following discussion at the meeting of 16 March 1928 of the Institution of Mechanical Engineers.

Discussion.

The discussion was opened by *Sir J. A. F. Aspinall,* who, in referring to his own early experiences at Crewe under Mr. Webb, at that time locomotive superintendent of the London and North Western Railway, said that, efficient as the shops were then, expansion had become imperative, and he understood that the recent extensions had well repaid the capital expended on them, and had resulted in even greater savings than were anticipated. The function of a large railway works was to repair locomotives, and not to build them, though the latter was done incidentally, as the accumulation of parts required for repairs enabled complete machines to be rapidly put together. As an example of the relative volume of repair and new locomotive work, it might be stated that the London, Midland & Scottish Railway had roughly 10 000 locomotives. If these needed repairs only once in two years that meant 5 000 locomotives yer year going through the various shops of the company. Assuming that the company had to renew its stock, and taking the average life of a locomotive as 33 years, 330 new engines would be required per year. The construction of these was a relatively small task compared with that of taking to pieces and putting together again the 5 000 locomotives repaired.

He considered that, great as had been the additions to the machinery at Crewe, a locomotive testing plant was still needed, and would be worth installing, seeing that 10 000 engines were concerned. With a trained staff of experimenters it was possible to observe on a plant an immense number of details which could not be watched on the road. The Great Western Railway had such a plant, and he would draw attention to the mass of information available on the results obtained from the well known testing plant of the Pennsylvania Railroad. The reports of the London, Midland & Scottish Railway for 1927, showed that about 5 000 000*l.* had been spent on repairs and renewalls, and an equal sum on fuel. The London & North Eastern Railway had spent 4 000 000*l.* on locomotive repairs and renewals and almost the same on fuel. He submitted that such an outlay of 10 000 000*l.* justified the expense of a locomotive testing plant, as even a small percentage of this amount, which might be saved as a result of researches with the plant, would effect a very great economy.

Mr. Francis Carnegie, following, thought that it would have been of advantage to engineers generally if the author had given some figures as to the actual savings obtained by the reorganisation. It would be interesting to know how many years it would take for these savings to recover the capital cost of the alterations and additions, taking into consideration the facts that under the new conditions the production costs and overhead and depreciation charges would be heavier. He thought that the generation of electricity on the site would have been cheaper than purchase from a public authority, and cheaper steam would have been obtained for steam heating and process work. He had found this to be so in the organisation with which he was connected. On the subject of progressive building, it seemed to him essential for the boilers to be put on wheeled trolleys. Otherwise it would be more advantageous to move the men rather than the heavy material.

Many engineers would doubt whether it paid to replace plain bearings by ball or roller bearings in existing works. He had had many difficulties with broken roller and ball bearings and damaged shafting, some twenty-five years ago when he had done this, and the result was discouraging. However, experience with new developments since 1912, had shown that these could now be fitted to run without trouble. Such bearings

had an increased mechanical efficiency over plain bearings of about 30 %. In a new plant the use of ball bearings was, he believed, justified, though, as they cost about twice as much as ordinary bearings, there were other than the mechanical considerations to take into account. In existing plant there was the difficulty caused by taking down the shafting for fitting the bearings for one thing; if split ball or roller bearings could be obtained the change might then be made with more certainty of it paying.

Reference had been made to carbon-steel tools with tips of high-speed; up to what size of tool had the author found these tips effective and durable? With regard tho the use of concrete paths for the electric trucks when the flooring was of wood, he had tried something similar in his own shops, but under heavy loads the concrete broke up. Calculations he had made for the method adopted of heating the shops showed that the heat loss from the roof was 75 % of the total heat of the steam. He had control of a shop, in size and construction similar to the large shops shown in the paper, heated by a floor-level system, and had calculated that he saved at least 30 % of the amount of steam it would require if heated by the overhead method described in the paper. With regard to the system of working to time at each stage of the work, and bearing in mind the large number of spare parts which were required, it would be interesting to know how the pre-arranged times were kept if, say, a casting was not available when it ought to be.

Sir Henry Fowler emphasised the fact that internal efficiency in the workshops became increasingly important as possibilities of extension diminished. At Crewe, one boundary was a street; other works on various railways were similarly handicapped, and it was necessary to improve the working of the shops, if only to utilise the space they had more advantageously. The new erecting shop was a departure from the old Crewe type with two bays and an arcade. The old shops were about 42 feet wide, the new ones over 60 feet. The arrangement was longitudinal, and there was a considerable amount of floor space apart from that occupied by the pits themselves. The floor was not used as a store, but was free for working on. Mr. Carnegie had raised the question of the recovery of the capital expenditure. This might be illustrated by comparing the annual reports of the London Midland & Scottish Railway Company for 1926 and 1927. There were from 400 to 500 more locomotives in service in the latter year, which was indicative of the efforts made towards efficiency with regard to engines under or awaiting repair.

Mr. F. A. Lemon said one or two questions had been raised regarding output. Engines standing waiting had been reduced from 13.2 to 7.02 %. This indicated that with the stock of 3 700 engines maintained at Crewe, a considerably increased efficiency had been reached. When the processing system was being considered, the men were consulted, representatives of the workshop committee and others being called in. The piece-work system was not possible as there was no basis to work on. The situation was explained, and the net result was that the first engine tried on the belt system was turned out with a reduction of 13.7 man-hours, and five minutes before its scheduled time. Subsequent improvements enabled the allowance made to the men to be raised from the 33 1/3 % originally agreed upon, to 50 %, a figure which was now being maintained. The spirit of the men was very good; all worked so as to ensure that no interruption occurred to the belt, as it was called.

Mr. F. E. Robinson asked what method was used for locating the posts employed

to determine the position of the horn-blocks on the erecting girders. Were dowels employed, and had steps been taken to see that, where the posts were bedded on the girders, they would not be affected by ordinary wear and tear? Were there hardened steel inserts, so that the posts were perfectly square? He also wished to enquire whether any special types of machines were employed in the production of the templates and jigs used. If reliance was placed on drilling and milling machines, what method of checking was employed to ensure the jigs being always to standard dimensions? As to mechanical boshes, he desired to know whether the method of washing was by means of an automatic washing machine where a conveyor was used, such as that employed by the London General Omnibus Company, or whether they were simply boshes in which the washing liquid was circulated mechanically? If a washing machine was employed, was caustic soda or other material used? His own experience of washing machines with conveyors was that a strong mixture of caustic soda and very fine sand was an admirable agent for removing all dirt, provided means of rinsing were arranged for in a following chamber.

On the question of processing, he had found considerable advantage in laying out works by the use of small lead models of the various machines, made to scale. When these were arranged on paper it was easy to utilise the floor space to the best advantage, particularly with regard to gangways, head-room, and routeing. Lines were traced on the paper round the models, the numbers of the machines added, and the plan was then sent to the millwrights responsible for the erection, the centre lines of any countershafts being also indicated.

Lieut.-Colonel E. Kitson Clark enquired as to the location of the weighing machine for the finished locomotives, and also what arrangements were made for the collection and disposal of the swarf? He thought the question of the heating of large shops rarely received sufficient attention. He had adopted the principle of floor heating by small pipes many years ago, but owing to the quality of pipes employed, the joints had proved leaky and the system had been troublesome. Were the glass roofs painted in any way to avoid excessive glare in summer? Another point which was often neglected was the disposal of the workmen's outdoor clothing. Were any arrangements made for this in the new shop? He had been unable to locate the boiler shop in the plan given in the paper, and it would be interesting to know the actual length of travel of the details through the shop. He agreed that the position of the erecting shop at the end of the works was correct. His own shop was in the middle of the works in accordance with the older ideas on the subject, but it had proved inconvenient.

Mr. S. J. Symes said that the whole lay-out of the works seemed to be to process the material from shop to shop, and through them with as little movement and labour as possible, and that a time had been fixed for the various operations, in accordance with modern ideas in manufacturing shops. This system had been adopted by Mr. Cecil Paget over twenty years ago at the Midland Railway Works at Derby. When an engine came in for repairs it was stripped and the boiler taken off; the frames were examined and then sent outside on the leading and trailing wheels, while all the work in connection with repairs to the boiler, motion, boxes, wheels, etc., was put on a time basis. The boiler was the governing factor as it usually took the longest to repair. Seven days before the boiler was finished, an advice was sent to the erecting shop which then worked on a schedule giving the exact date on which each part was required, special gangs of

men being employed on the different jobs.

The number of engines allocated to the shop was 60 at that time, and Mr. Paget fixed the output at 20 per week. The shops at Derby were old and were not laid out as at Crewe. The present system was a modification of that introduced by Mr. Paget. There were three bays in the erecting shop and 13 engines were dealt with in each bay, which meant an output of eight engines per week each when working on repairs. If all were so employed, the total output was 24 engines per week. Each bay had two roads, and was divided longitudinally into three sections. On reaching the shop, the engines were stripped and put on the first section, which was a frame section. In the second section the boilers were fitted, cabs and splashers put on, etc. In the third section, the motion and wheels were put in and the engine finished. Four engines were moved on and off each section every three days, different times being adopted for each bay to make the output more continuous.

Mr. R. E. L. Maunsell said he would confine himself to one or two questions. How were the parts stripped from the engines collected and distributed to the responsible shops, and how were the departmental foremen advised with regard to the date on which they were required back in the erecting shop ? Apparently the boilers were taken out of the frames in every one of the repairs. His own experience was that in many instances the boiler was in a sufficiently good state of repair and dit not need to be removed from the frames. Further, were the following items mentioned in the paper essential in every general repair ? — taking out drag-boxes, frame welding, welding cracks in cylinders, removing and refitting steam chest liners, and hornblocks. If so, it did not agree with his experience of repair work. If such parts as these did not need attention or the boiler did not have to be taken out, it would upset the time required for the different stages. How was unused time filled in ? Again, how was extra time allowed for, when say, a new pair of cylinders had to be fitted ?

Returning to the question of the boiler, it was taken out in stages 1 or 2, and had to be replaced four days later. Boiler repairs might involve a new set of tubes, a new firebox, a new tube plate. It seemed hardly possible to effect these repairs in the time allowed. It might be that the 6 % of spare boilers provided would cover these cases, but he thought they would hardly cover a succession of heavy repairs. No reference had been made to testing boilers. Were the boilers tested in the boiler repair shop, or in the new erecting shop ? If the latter, that seemed to be an additional operation not provided for. Evidently the tests were carried out with spare mountings, but he would like further information on the whole question of testing.

The President then said that he had, with regret, to ask Captain Beames to reply to the discussion in writing.

[621 .138.5 & 725.33]

The longitudinal shop.

(*Engineering.*)

The old discussion of the longitudinal *versus* the transverse shop for locomotive repairs assumes a new aspect in view of developments such as those related by Captain H. P. M. Beames, in his paper read on 16 March 1928 before the Institution of Mechanical Engineers (1). If, indeed, such methods are to become general, the doom of the transverse shop must surely be sealed. The arguments in favour of placing repair pits lengthwise down an erecting shop, or crosswise, have varied from time to time, as mechanical developments have followed each other. The transverse pit arrangement certainly presents considerable attractions. So disposed, a very compact shop is possible, and all the pits are equally accessible from side aisles by means of which communication may be maintained with feeder departments. There are more points perhaps on the other side. Unless the shop is provided with a traverser, the track approach occupies a great amount of space. If a traverser is provided, either inside or outside the works, a large area has to be kept clear. If this is inside the shop, the space is roofed in but contributes little actually to production, while it breaks up the floor badly for the movement of material. Most locomotive men are only too well acquainted with cases in which the size of engines has outgrown the length of pits provided on the transverse system. For this defect there is no remedy short of rebuilding. No projection can be allowed, of course, at the traverser end, if there is one, and the locomotive has to be pushed back towards the side aisle, where lifting may become impossible, and if actual obstruction does not result, almost certainly there will be congestion.

In cases where shops have been designed on modern lines, with the transverse arrangement, and allowing ample room round locomotives of present-day length with something to spare, other points claim consideration. The transverse arrangement has been largely, though not exclusively, adopted in the United States. There, traversers are discarded, and use made of powerful overhead cranes, but this arrangement means that each locomotive has to be handled by a single crane, which consequently must be of 150 t. or 200 t. capacity, with a span of 85 or more feet. If ample allowance is to be made for the future, the cost of a shop and equipment on these lines becomes a very serious item, and it must be noticed that height also comes into the question, though in this matter of costs increased height is not so expensive as increased span. With the American type of transverse shop engines must always be lifted to a height of about 15 ft. 6 in. to clear any already standing on the pits, some of which may even be jacked up, when the lift would be higher.

Some years ago the American Railway Master Mechanics inquired into the relative merits of the two arrangements as they affected practice across the Atlantic. Speaking generally, the factors bearing on the question must be approximately the same there as here, though we

(1) See page 665 of this issue.

are probably oftener driven to make the best use of restricted space, while they, on the other hand, have experienced a very much more rapid growth in the length and weight of their locomotives, both factors of greater importance with the transverse than with the longitudinal shop. The Master Mechanics' Committee issued a report on the subject, substantially in favour of the longitudinal shop, but admitting certain advantages of the transverse plan. However, we believe the report was not considered in any sense decisive, and, in fact, was subject to a good deal of criticism, which it must be admitted bore at least a logical aspect. It was almost a case of six of one and half-a-dozen of the other.

The longitudinal shop is an attractive proposition. It usually has three tracks, at least two with pits, the centre track in theory being reserved for stripping and wheeling. The width of the shop is thus set definitely, and does not tend, with the passage of time, to shrink relatively. No increase in loading gauge is possible, and all the room that should be necessary can be decided upon without fear of shortage at some time in the future. It is true that in some logitudinal shops the allowance of space between the roads has been barely sufficient. This involves considerable delays when moving engines down the shop, unless the height of the building is again sufficient to enable everything to be cleared. One of the more material advantages of the longitudinal plan is undoubtedly its flexibility lengthwise. In the repair programme all kinds of engines have to be handled. Larger, medium size, and the older and smaller types have all to be taken in hand. In the transverse arrangement the room to spare if a short engine is on a pit, cannot be added to that wanted for a long engine next to it, and is thus wasted, but this is not the case in the longitudinal shop, where, though stations are kept, some latitude is possible.

The great snare of the longitudinal scheme is that the floor space often tends to become littered up with parts, while if the work increases, there is a temptation to put engines on to the centre road. If, on the other hand, the centre road is always kept clear, advocates of the rival system contend that the space is inefficiently used. For expeditious work there is little doubt that this road should be kept clear, while the stacking of parts on the working floor should be prohibited, much as some would like relaxation of the rule at such times as directors' inspections, for tactical reasons. In any case, if comparison be in question, it must be remembered that in the transverse plan room has commonly to be allowed for wheels, etc., preparatory to wheeling and these stand waiting on the end of the pit track. The congestion of shops by waiting material is in either case unpardonable. At the Institution on 16 March 1928, Sir Henry Fowler said the secret of the success of the Crewe arrangement was having what you wanted, where you wanted it, when you wanted it. The old plan of keeping work lying on the floor may also have fulfilled these essentials, but without contributing in any way to expedition, so that the definition is hardly, we think, complete as it stands. The Crewe plan arranges for the parts to come together when wanted, but not before.

This plan, worked on a so-called « belt » system, is only possible with the longitudinal shop. There would seem to be no reasonably simple method by which it could be introduced into a transverse shop. Clearly, if the work can be reduced to so precise a system, there is much to be gained by avoiding the movement of gangs. Feeder departments also always deliver to the same spots. Similarly, there is a considerable economy of time and equipment by locating definite processes at fixed points. Captain Beames touched on this point in his paper, and any erecting shopman will

readily visualise the savings possible from not having to hunt about the shop for special gear, which, however strict rules may be regarding its return to certain places, spends most of its time else where.

The chief point against the belt scheme is that made by Mr. Maunsell in the discussion. It is a little difficult to see at once how the work done at the first four pits is to be balanced so as to give a regular flow forward to the further stages. It is true that all the work tackled comes under the heading of heavy repairs, in which class, in at any rate many works, lifting the boiler would be included as a matter of course, but custom in these things varies somewhat, and it can only be regretted that at the meeting of 16 March 1928 Captain Beames was not afforded the opportunity of giving the explanation necessary to clear this up. Certainly the system seems to be working satisfactorily at Crewe. In spite of something like 17 classes being dealt with on these lines, engines are leaving the shops régularly and without a hitch although all sorts of last-minute possibilities suggest themselves to the onlooker. The officials at Crewe are much to be congratulated on this, as also on having gained the interest of the men in the new scheme. This having been secured, a good part of the battle must have been won.

Since the amalgamation the question has often been asked : What are the railways doing to economise ? The London, Midland and Scottish Railway can, at least so far as its mechanical departments go, offer some very good replies on the point. The wagon and carriage building methods, and now the locomotive repair system, are all of the most advanced character. We are often directed to the United States for progressive production processes but nowhere in that country will anything be found to touch the developments at Crewe, and in most present works such schemes would, forsooth, be quite impossible. Its general introduction is precluded by the preference which has developed there for the transverse pit shop. This may be regarded merely as a temporary handicap, for if the idea « took on », as the saying goes, wholesale scrapping and reconstruction would immediately follow, after the well-known practice of our transatlantic neighbours.

[**625** .258 (.73) & **656** .259 (.73)]

Car retarders at Selkirk Yard,

By R. B. ELSWORTH,

ASSISTANT SIGNAL ENGINEER, NEW YORK CENTRAL LINES, ALBANY, N. Y.

Fig. 1, p. 685.

(From *The Railway Age.*)

A car retarder installation was placed in service by the General Railway Signal Company for the New York Central Lines on 16 January, at the westbound classification yard at Selkirk, N. Y. This location was selected after a thorough consideration of various yards on the New York Central, subsequent to the initial installation at Gibson, Ind., on the Indiana Harbor Belt. Selkirk Yard

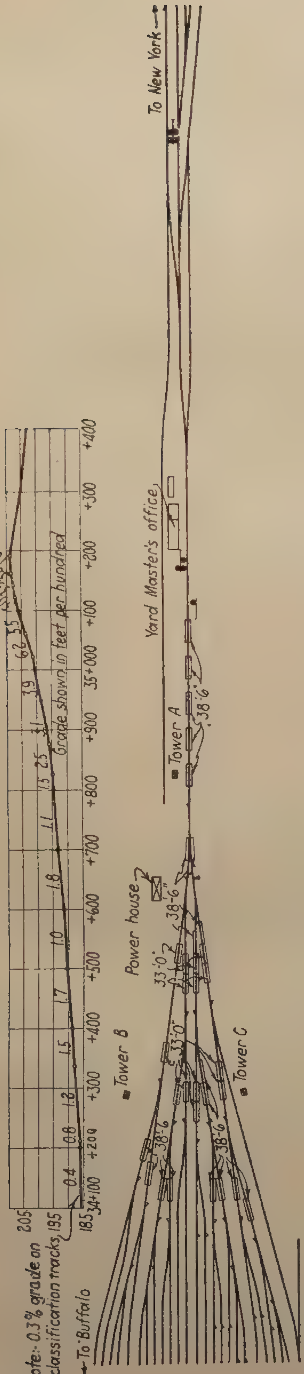

Fig. 1. — Track and signal plan showing track layout, grades and location of the retarders.

is located approximately 10 miles southwest of Albany on the new cut-off leading from the A. H. Smith Memorial bridge to the main line of the Mohawk division of the New York Central, west of Schenectady. The yard is at the junction of the freight connections from the Boston & Albany, the Hudson division of the New York Central leading from New York direct, and the River division of the West Shore from the New Jersey side of the New York terminal district.

The westbound yard at Selkirk, is made up of a receiving yard of 15 tracks, a classification yard of 25 tracks and an advance yard of 15 tracks. Two leads extend from the receiving yard to the crest of the hump, in order that a second train may be ready as soon as the preceding train has been classified. Approximately 80 % of the cars handled over the westward hump are empties, the major portion of the loads being detoured around the hump for classification at other points. At the present time approximately 1 700 to 1 800 cars are being classified on the hump daily.

Prior to the installation of car retarders, car riders were used and the switches were operated by General Railway Signal Company electric switch movements controlled from a desk lever machine on the second floor of the yardmaster's office at the crest of the hump. This system had been operating satisfactorily since the yard was constructed, approximately four years ago.

The transfer of the control of the switches from the yardmaster's office to the new towers was made one week before the car retarders were placed in operation in order that operators might become familiar with the new arrangement of the switch controls before being required to operate the retarders. The change from the car riders to the car retarders was made at 8 a. m., 16 January.

Retarders permit two-trick operation.

The car retarder installation demonstrated its efficiency on the first day, and at the end of three weeks, operation was placed on a two instead of three-trick basis. By operating the yard on a two-trick basis, 8 a. m. to 4 p. m. and 8 p. m. to 4 a. m., there is no material delay in car movements through the terminal and time is provided between tricks for locomotives to go to and from the roundhouse, thereby reducing the number of locomotives necessary for operating the hump.

The capacity of the yard has been increased 50 % by the installation of retarders, which will permit additional savings with any increase in business. Although the operators are not yet thoroughly proficient in the operation of the installation, more than 900 cars are often classified in over 600 cuts during an eight-hour trick.

When a train arrives in the receiving yard, the conductor transmits to the yardmaster's office a summary of his running slips, showing the consist of the train. This list is teletyped to the three operating towers from a master typewriter in the yardmaster's office, so that when a train starts up the hump to be classified, the yardmaster, the operator at each tower, and the yard conductor at the top of the hump, know the entire consist of the train, including the number of cuts, the car numbers, the approximate weight of each car, and the track on which it is to be classified. The weight of the car indicates in a general way the amount of retardation which will have to be applied.

The hump grades required at this location are of particular interest. The natural slope of the ground is ascending for westward movements, making it necessary that the crest of the hump be on a fill 45 feet above natural ground surface. The difference in elevation between the top of the hump and the first switch at the bottom, is about 14 feet, the grade between these two points varying from 6.2 % at the top to 1.5 % at the bottom. The 1.5 % grade continues through the retarders after which it changes to 0.5 % and finally to 0.3 % on the classification tracks.

The prevailing winds are from the west and southwest and are frequently very strong, imposing a considerable resistance to car movements, due to the exposed location of the hump. While the grades must be steep enough to handle empty cars under the winter conditions with an unfavorable wind, sufficient retardation must be provided for a 70-ton car moving under the most favorable conditions. The grade of the classification yard has been made 0.3 %, but it is possible that, in order to get satisfactory movements with the empties, it may be necessary to increase this to 0.35 %.

The determination of the track and switch layout was influenced by the desirability of making use of as much of the arrangement already in service as was consistent with the requirements of the new layout. Sufficient distance was allowed between a switch and a retarder for the locking-up track circuit. Space was provided for switches leading to six additional tracks on the north side and two additional tracks on the south side of the yard. It was also decided not to use lap switches or any switches shorter than No. 8.

With the type of retarder employed it is not practicable to use a standard rail joint within the limits of retarder, and such joints are welded. In order to keep the number of welded joints to a minimum and effect the greatest economy of space with proper track circuit locking, a detail plan was prepared specifying the exact length of each rail in the vicinity of the switches and the location of each rail joint. This plan was of material assistance in providing correct material and making a quick and economical installation.

There are sufficient retarders on the south side of the yard for handling 70-ton loaded cars on any track. The north side is equipped for retarding empty cars only. In several cases it was possible to install a retarder on the lead of a turnout so that a one-rail retarder could be used. Where these are used, a guard rail is placed parallel with and along the opposite rail to avoid the derailment of a car which may have been lifted by the retarder.

Retarders controlled from three towers.

The installation is electrically operated and controlled from three towers; Tower A, located about half way up the hump and Towers B and C, at the foot of the hump on either side of the yard. The towers are 8 ft. 6 in. by 10 ft. 6 in., built on a steel frame; the floor of Tower A is 13 ft. 6 in. above the rail and the floors of Towers B and C, 20 feet above the rail. Iron stairways are provided around back of the buildings and plate glass windows at each end and on the track side. Heat is provided by electric heaters. The towers are of fire resisting construction.

The face of each tower control machine is set at an angle of approximately 30° from horizontal and has three rows of levers, the top row for the control of the skates, the centre row for the five positions of the retarders, and the bottom row for the switches. Spare spaces are provided in the control machines for additional switches, retarders or skates which may be required.

There are 33 car retarder units, 14 of which are double retarders 38 ft. 6 in. in length, 14 double retarders 33 feet in length, and 5 single retarders 38 ft. 6 in. in length. The double retarders are installed on both rails of the track and the single retarders along one rail only. Contactors for the retarder operating apparatus are mounted in a sheet iron box supported by two concrete posts adjacent to each retarder. The five double retarders on the hump proper, two single retarders, and the three junction switches, are controlled from Tower A, the remainder of the switches and retarders are divided along the center line of the classification yard, between towers B and C.

Motor-operated track skates, for the purpose of stopping a car which may not have been properly retarded, are provided on the 12 tracks on the south side of the yard intended for loaded cars.

The retarder apparatus is of the latest improved General Railway Signal Company design similar to that installed at Mechanicville, N. Y., on the Boston & Maine as described in the *Railway Age* of 4 February 1928, page 295 [1]. The retarders themselves are rugged and so designed that in case a car is lifted due to excessive retardation, the flange will be held until the car may drop back on the rail.

Flood lights for car rider operation which had been in service on steel towers, throwing light parallel to tracks, were transferred to the roof of operating towers to afford maximum illumination for operators in observing car numbers and speeds.

A two arm color-light signal is located at the crest of the hump for controlling the engine which is pushing cars over the hump. Three indications are given with the top light : green, « Normal Speed »; yellow, « Slow Speed », red, « Stop ». Yellow on the lower light indicates « Back Up ». Repeater signals are located at the throat of the receiving yard 1 600 feet in the rear of the hump. A signal facing the classification yard indicates yellow when the movement of the trimmer engine toward the hump is desired.

A loud speaking telephone installation

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(1) See *Bulletin of the Railway Congress*, July 1928 number, p. 574.

provides telephone service in each of the towers and on the ground at the crest of the hump. The telephone installation was made in duplicate throughout, to provide for emergency operation in case of a failure of one set. The teletype system installed for printing car lists is also in duplicate, with machines in each of the operating towers controlled from the yardmaster's office.

Locking prevents switch operation under car.

Track circuits, beginning 25 feet in the rear of each switch point and extending 8 feet beyond heel of the point, are provided for preventing the operation of a switch beneath a car or engine. A repeater, adjacent to the machine lever in the tower, indicates when the track circuit is occupied. Due to the desirability of making these locking circuits as short as possible, both to keep down overall length of switch layout and to permit minimum safe headway between cars, the distance between the insulated rail joint and the switch was limited to 25 feet. Under such conditions a normal track circuit will not shunt quickly enough to prevent throwing a switch beneath a fast moving car. After extensive investigation a reliable circuit was developed, such that a car wheel passing over the insulated joint at end of the circuit, causes the practically instantaneous pickup of the relay and prevents the starting of switch operation until all the wheels have passed off the circuit.

The track switches are operated in slightly less than one second by G-R-S Model-6 switch machines. By changing to a faster motor, this time may be reduced approximately one-half, in case operating conditions make this desirable. The quicker acting switch, due to the greater strain on the parts, requires more care and an earlier renewal than is the case with standard machines.

The retarders are operated normally by 250-volt direct current supplied from a 30-kw. General Electric motor generator set. The generator sets are in duplicate, only one set being operated at a time. Each set will withstand an instantaneous demand of approximately 300 amperes which will care for the operation of the maximum number of car retarders required at one time. The motors of the motor generator sets are operated by 440-volt, 3-phase, 60-cycle alternating current, stepped down from the 6 600-volt local yard power line. A 110/125-volt storage battery supplies power for the operation of the switch machines.

Under normal operating conditions the car retarder and switch operating circuits are completely separated. In case of a power failure or the stopping of a generator, control switches will automatically connect the two 100-cell sets of storage batteries in series and then make the connection to the car retarder feeders, thereby insuring continuous current supply. This arrangement of power supply is desirable in carrying out car movements which may be under way at the time of a power failure. The storage battery will operate the switches and retarders for several hours. When, after a failure, power is restored, the automatic control restores the plant to its normal operating condition, cutting out the storage battery and starting the generator.

The assembled switchboard is 10 feet long, 6 feet high and in accord with the A. R. A., Signal Section switchboard standards. The operating batteries arranged in duplicate sets are charged by a 40-ampere mercury arc rectifier, the maintainers being instructed to alternate the switch operating load between the two sets of battery so that all cells will be kept in good condition, and nearly charged at all times. The 100 cells of storage batteries are the nickel–

iron-alkaline type of 300 ampere-hour capacity as manufactured by Thomas A. Edison, Inc.

The car retarder installation, complete with power supply, was made by the General Railway Signal Company in accord with plans and specifications of the New York Central.

[388. (09. (52)]

RAILWAYS OF JAPAN.

Figs. 1 to 8, pp. 694 to 703.

(From *Modern Transport.*)

Fifty years of railway construction.

An historical review.

The honour of the introduction of railways into Japan belongs to an Englishman. The credit for their initial construction is also due to an Englishman. The origin of railways in Japan may be said to date from the year 1868. In that year Sir Harry Parks, then British Minister Plenipotentiary in Tokyo, persuaded the Japanese Government to embark upon railway communication. On his advice, the Government formulated a plan to lay a trunk line from Tokyo through Kyoto (the old midland capital) to Kobe (the nearest port on the Inland Sea), together with branches from Tokyo to its neighbouring port of Yokohama, and from Kyoto to Tsuruga, a central northern port on the Japan Sea. As the first step, £500 000 was apportioned for the work between Shimbashi (Tokyo) and Yokohama, but the State Treasury was not in a position to afford the outlay, while private capital declined to venture upon what was then a novel field for investment. At this juncture an Englishman, named Horatio Nelson Lay, came forward with a proposal to furnish the required funds. His terms were accepted, and a Japanese loan for £1 000 000 sterling was placed on the London market. Upon the arrival of a British engineering corps from the British railways with materials, the first sod was dug on the 18-mile Shimbashi (Tokyo)-Yokohama-line in March 1870, and on the Kobe-Osaka section of the trunk line in the following November. The gauge adopted for the lines was one of 3 ft. 6 in., which has ever since been the standard gauge of the Japanese railways.

The first decade.

The line between Tokyo and Yokohama was completed and put into operation in September 1872, forty-seven years after the inauguration of the railway era in England, and forty-two years after the first railway in the United States of America opened its service. The Kobe-Osaka section commenced operation in 1874, and an extension to Kyoto was completed in 1877. These sections formed the nucleus of what now constitutes the Tokaido line, one of the main arteries of traffic in Japan. The Govern-

ment experienced much difficulty in procuring funds for further railway enterprise, and a succession of troubles, including the Formosan expedition and the disastrous rebellion in South Japan, brought railway building practically to a standstill. As soon as order was restored to the country, £300 000 were appropriated out of a domestic industrial loan, and railway construction was recommenced. By 1884 Tsuruga, the central northern port, was brought into railway connection with Kyoto by the help of a steamer service across Lake Biwa, and a 55-mile section was also opened to traffic. The first decade of railway building came to a close with 115 miles of track entirely under Government ownership.

The coming of private railways.

But about this time the State Treasury once more found itself unable to provide further capital. It was under these circumstances that the Government decided to depart from its policy of State building, and granted a concession to the Nihon Railway Company. This pioneer private railway was organised in 1881 with a capital of £2 000 000. The project was an ambitious one for Japan at that time, comprising the construction of railways totalling 510 miles in length. The company was granted land for railways, and interest payment up to 8 % was guaranteed for ten years. On the other hand, strict and comprehensive control was ensured by the Government over all phases of railway business, including construction, accounts, and rate-making. The term of the concession was fixed at ninety-nine years with an option for State repurchase after fifty years. The satisfactory results achieved by the Nihon Railway stimulated private enterprise, and by 1891 as many as fifteen companies had received charters. All these were indebted for their growth to the policy of State encouragement in the shape of guarantees of interest between 4 % and 8 % or cash subsidies. In fact, during the period between 1883 and 1906 the Government defrayed £1 250 000 for subvention to the private railways. The progress of railway ventures experienced a serious check at times owing to economic crises in the country. Nevertheless, railway building was steadily carried on by the big companies and, in the ten years between 1881 and 1891, 1 165 miles of track were built by private capital, a length more than double the State mileage, which did not exceed 551 miles. This was an undoubted success, and so far constituted a favourable comment upon the wisdom of the authorities in adopting the expedient of State aid to private enterprise.

First movement for nationalisation.

The question that next demanded the attention of the authorities was how the private lines, mostly short, disconnected and scattered throughout the country, might be extended and organised into through lines under a unified system and how efficient service might be ensured. As a first step towards securing uniformity of operation under State control, the individual concessions made to the different companies had been codified by the issue of special regulations in 1887. This legislative work did much so far as the effective control of private enterprise was concerned, but proved inadequate for realising the desired co-ordination. The demand for the speedy development of railways was still as urgent as ever, in view of the industrial progress of the country, as many as 3 600 miles being yet needed to complete the railway network over the whole country. The bulk of these contemplated lines was in remote districts, with no prospect of immediate profit, and on that account not appealing to private enterprise. These circumstances showed both the Government and the public the

advisability of State acquisition of the private lines, and the opinion was further strenghtened by the financial failure of some of the private companies. This was the first movement for nationalisation in the history of Japanese railways.

Foundations of the present system.

Two Bills were introduced in the Diet of 1891 providing for a loan for the State construction of 799 miles and for the purchase of private railways. They were both rejected that year, but in the following year the Loan Bill was passed with radical modifications, and the Acquisition Bill again thrown out. The Loan Bill enactment was entitled the Railway Construction Law, and it laid the foundations for the railway system as it exists to-day. The law authorised the Government to raise a loan to the extent of £6 000 000 to meet the expenditure on the first period work, and it also provided for the purchase of such private lines as were judged necessary to realise the projected network of railway co-ordination. The co-operation of private enterprise was allowed, on the other hand, for the building of some of the routes specified in the programme. Under the stimulus of this Law private building went on apace. The construction of 670 miles of the routes specified in the railway programme of the Government was undertaken by private enterprise down to the fiscal year 1905 ending 31 March 1906. The general economic boom, brought about by the military success over China in the China-Japan War of 1894, was specially marked by railway speculation. Then came the reaction. In the year 1898-1899 no fewer than fifteen railway companies were dissolved owing to their failure to raise capital funds. The process of absorption or amalgamation reduced the number of the private companies from 66 in 1897 to 39 in 1906. Thus the stage of big systems arrived for Japanese railway enterprise. Altogether, the mileage constructed by private enterprise during the 24 years from the commencement of the first private railway down to the end of the fiscal year 1905 (31 March 1906) aggregated 3 248 miles, being more than three-fifths of the entire railway network of Japan.

Movement towards consolidation.

All the while the move for consolidation, though apparently left in abeyance, was in reality in the process of maturing. The project was again resuscitated in 1899, when a comittee of inquiry appointed by the Government reported in favour of State acquisition of the trunk lines. In 1900, two Bills for nationalisation and State purchase were placed before the Diet, but, owing to political complications, they failed to pass. In the same year, however, two laws, entitled the Private Railway Law and the Law relating to the Operation of Railways, were enacted, which abrogated and incorporated into themselves all the regulations then in force. The two laws still remain valid. The Private Railway Law clearly defined the policy of State regulation of private enterprise, fixed the maximum third class fares at a halfpenny per mile, and brought ratemaking under the supervision of the Minister. The Law relating to Railway Operation extended the scope of State supervision over all phases of railway business, established vital relations between the State and private enterprise, and placed them under uniform control. Then the question of unified railways came to the fore for the third time. The principle of Government ownership of the railways was now almost generally conceded, but public opinion was much divided on the issue as to whether the railways could be worked with greater efficiency under Government than under

private management. The opinion of the militarists, from the point of view of national defence, further enlivened the discussion. Then broke out the war with Russia in 1904, which thrust all industrial matters into the background.

Railway nationalisation achieved.

The national spirit of expansion engendered by the successful war with Russia, and the need of the times for the speedy development of national industry, supplied a determining factor in the final solution of this outstanding problem of railway nationalisation. Of the total length of 4 784 miles then under traffic in the year 1906, 3 248 miles were divided among thirty-eight different companies, and the lines were mostly short and disconnected. Even the Government lines were separated from one another by intermediate private railways. Under these circumstances, the proper development of through traffic was practically out of the question. In March 1906, the Government, then under Marquis Saionji, placed before the Diet two Bills for nationalising all the leading private railways in Japan and the Korean line from Fusan (the Korean port across the narrow strait from Shimonoseki, Japan's most westernly point) to Seoul (the midland Capital of Korea), which had been built and managed by Japanese interests. The circumstances were exceedingly favourable, and, as the Government had the unqualified support of the majority party in the Lower House and the militarists, the Nationalisation Bill was passed by both Houses on 31 March 1906. The acquisition of the private railways was accomplished by October 1907, and at the same time the subsidiary business was also taken over. As might be expected, various claims were advanced by the companies in settling the purchase price, but they were all settled by amicable arrangements, and not one case was referred to the Arbitration Committee provided for in the Bill. Seventeen private railways were thus purchased, their total mileage aggregating 2 823 miles, and the total price paid amounted to £48 million 465 000.

Results of nationalisation.

Table I shows the results of nationalisation :

TABLE I.

For year ending 31 March.	1906 (including returns of the purchased railways).	1914	1926
Average mileage worked	4 314	5 348	7 692
Number of passengers carried	97 701 960	167 773 143	677 085 503
Tonnage of goods hauled	20 278 673	36 348 362	71 939 246
Passenger-miles	2 381 339 652	3 690 964 619	11 645 130 433
Ton-miles	1 333 378 644	3 053 852 638	7 226 686 969
Earnings per mile	£ 1 536	£ 2 079	£ 6 241

Immediately after the nationalisation the State railways were reorganised under a Railway Bureau, which was directly responsible to the Cabinet. But in May 1920, a separate Department of State was created to deal with railway affairs, and the Ministry of Railways has been the administrative authority up to the

present time. On 31 March 1927, the end of the last fiscal year, the Japanese Government Railways covered 8 000 miles with 200 000 employees. In addition, there were private railway companies' lines aggregating 4 881 miles; so that Japan has now 12 881 miles of railway lines open to traffic. Comparing these figures with those for 1887, when there were only 240 miles of railway and little more than 1 000 employees, the progress of railway construction in Japan during the past half-century is positively amazing, the average rate of progress being more than 250 miles per annum.

Railway workshops.

Modern equipment for repair of locomotives and rolling stock.

Throughout the Japanese Government Railways there are twenty-one main establishments for the construction and maintenance of locomotives and rolling stock and four subsidiary depots, all of which possess the latest plant and equipment. Their disposition is as follows: For the Tokyo Region, works at Omiya, Oi and Kinshicho, with a subsidiary plant at Sumidagawa; Nagoya Region: Nagoya, Hamamatsu, Nagano and Kanazawa; Kobe Region: Takatori, Suita and Goto with subsidiary plants at Tokushima and Tadotsu; Moji Region: Shimonoseki, Kokura, Wakamatsu and Take (near Kagoshima); Sapporo Region: Naebo (near Sapporo), Goryokaku (near Hakodate), Asahigawa and Kushiro, with a subsidiary plant at Wanishi. On 31 March there were 2 615 officials, including works managers, 12 527 workmen and 781 labourers employed at the foregoing works, and out of a total of £987 645 paid in wages, £694 815 was represented by piece-work. The average number of working days per head throughout the year amounted to 311.4, the average wages per working day being 5s. 1d. During the same year 3 726 steam locomotives, 78 electric locomotives, 9 873 passenger coaches, 1 274 electric cars and 67 645 wagons passed through the shops for repair. So far very little new construction is being undertaken by the railway administration but during the year in question forty passenger coaches and twenty-three goods wagons were built and a number of steam and electric locomotives erected. One of the largest plants is that at Oi, which comprises carriage and wagon repair shops and is situated just outside Tokyo (fig. 2). The ground covers an area of 71.6 acres, and the buildings 12.3 acres, with 15.3 miles of track The largest locomotive and car repair shops are, however, those at Omiya, near Tokyo, of which an illustration is also given (fig. 1).

System of accounts.

Railway finance segregated from State budget.

The railway budget in Japan is kept entirely separate and distinct from the general finances of the State. This independent administration has been in force since 1909, when it was inaugurated under the Imperial Railway Account Act. This Act decreed that the Government railways undertaking, like any com-

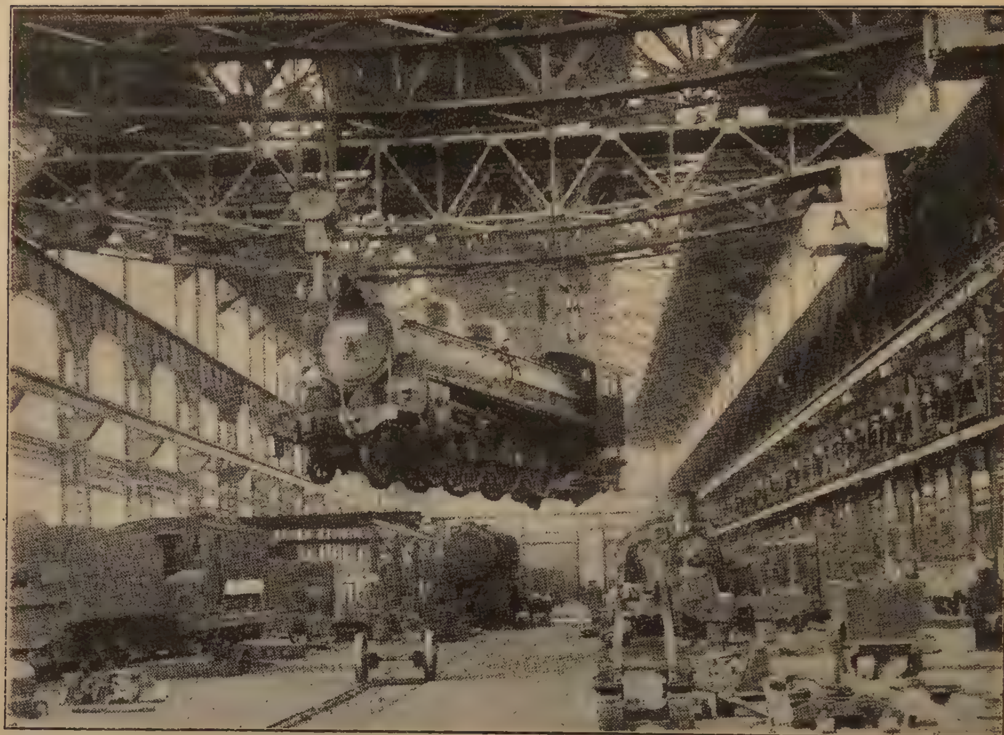

Fig 1. — The locomotive and rolling stock works are of modern design and construction; the above is a view in the erecting shop at Omiya.

Fig. 2. — Truck shop, Oi carriage and wagon works.

mercial enterprise, should pay its working expenditure and make disbursements for new construction and improvements out of the revenue accruing from the business. It is realised, however, that the railways are still in course of development, and as it is found impossible to meet capital expenditure on improvements out of revenue the deficit is supplemented by the proceeds of public loans, issued as a charge against the railway finances, as well as of floating loans derived from the other resources of the State. A general idea of this arrangement will be gained by reference to table II; it is to be noted that the fiscal year ends on 31 March and that the basis of conversion to British standards is 10 yen to the £1 :

TABLE II.

Japanese Government Railways: Yearly revenue and loans (in thousands of £).

Fiscal year.	Revenue.	Public loan.	Floating loan.
1909	942	196	2 014
1910	1 233	...	2 450
1911	1 975	3 000	...
1912	1 913	3 500	500
1913	1 929	...	2 030
1914	1 375	...	1 855
1915	2 372	...	2 000
1916	3 459	...	2 000
1917	4 309	1 900	...
1918	4 291	2 549	...
1919	5 939	3 859	...
1920	5 386	9 417	500
1921	11 554	9 114	...
1922	13 153	6 375	...
1923	11 026	3 969	2 500
1924	12 982	4 903	...
1925	14 326	3 667	1 400

It may be observed that the decision to afford financial independence to the Government railways was based on the need for giving every encouragement to their development, this being considered essential for the welfare of the community. The railways, it was conceded, should not be affected by any other financial enterprises of the State, and every possible facility was given for the raising of the funds necessary for their progress. The beneficial results of this decision are to be seen in the remarkable development of the Government Railways in the comparatively short period of fifty years since their inception.

Capital.

The capital of the Japanese Government Railways at 31 March 1926, stood at £250 015 461. It is classified under two headings, capital proper and debenture capital. The debenture capital corresponds to the liabilities at the charge of the railway account including public loans, floating debts and loans issued for the purchase of private railways. The remainder forms the capital proper, which embraces, for instance, the net profit transferred from the revenue account, the proceeds of the sale of property, redeemed debentures and surpluses on the stores account. Of the sum mentionned above, £109 674 070 represents capital proper and £140 341 391 debenture capital.

Accounts.

The accounting system of the Government Railways provides for the keeping of three main accounts, namely, the capital, stores, and revenue accounts. The capital account is for the purpose of consolidating the expenditure on railway construction and improvement; the revenue account shows the results of railway working; and the stores account is concerned with the supply of railway

TABLE III.

Financial results of railway working.

Fiscal year.	Gross receipts.	Working expenses.	Profit.	Operating ratio.	Percentage of profit to capital.
	£	£	£	Per cent.	
1909	8 223 644	4 469 982	3 753 662	54	4.8
1918	24 354 730	15 630 341	8 724 388	64	6.8
1919	30 993 191	20 515 297	10 477 894	66	7.6
1920	35 069 958	24 687 925	10 382 033	70	6.7
1921	39 759 949	22 724 629	17 035 320	57	9.6
1922	42 959 399	23 866 478	19 092 921	55	9.7
1923	44 335 478	26 798 217	17 537 261	60	8.2
1924	47 092 724	27 282 799	19 809 925	58	8.5
1925	48 045 090	26 545 948	21 499 142	55	8.6

TABLE IV.

Details of revenue (in thousands of £)

Fiscal year.	Passenger traffic receipts.	Goods traffic receipts.	Miscellaneous receipts.	Total.
1909	4 351	3 752	120	8 224
1918	12 339	11 213	803	24 355
1919	16 661	13 501	831	30 993
1920	20 784	13 740	546	35 070
1921	21 923	17 114	723	39 760
1922	23 745	18 357	857	42 959
1923	25 528	18 118	688	44 335
1924	26 473	19 926	694	47 093
1925	26 822	20 443	779	48 045

stores and materials. The capital account is credited with the net working revenue, representing the balance of the revenue account; with the proceeds of public and floating loans and of sales of railway property; with the surplus of the stores account and with miscellaneous receipts. It is debited with the amounts expended on construction and improvement, with sums afforded to the redemption of loans, and with any adverse balance carried from the stores account. It is of interest to note that during the fiscal year 1909 the amount expended on new construction was £2 125 324 and on improvements £524 526, the amounts under these heads for 1924 being, respectively, £5 729 173 and £13 264 079 and, for 1925, £4 477 219 and £14 540 908.

Stores and revenue accounts.

For the purposes of the stores account the railway department makes an allocation, which at present is fixed at £2 233 694, for the purchase and manufacture of materials. As requisitions are received, the materials are charged up to the account of the department making the demand and credited to the stores account; in this manner the supply business of the railway is kept independent of other activites. The revenue account

TABLE V.

Average revenue and expenses per day and per mile. 1923-25.

		1923.	1924	1925.
		£	£	£
Working revenue.	Per day	121 135 2	129 022 2	131 630.4
	Per mile	6 205.5	6 329.5	6 241.0
	Per day, per mile	16 96	17 34	17.1
Working expenses	Per day	71 377.7	72 940.4	71 079.4
	Per mile	3 656.6	3 578.3	3 370.4
	Per day, per mile	9.99	9.80	9.23
Profit.	Per day	49 757.5	76 081.8	60 551.0
	Per mile	2 549.0	2 751.2	2 871.2
	Per day, per mile	6.96	7.54	7.87

TABLE VI

Analysis of working expenditure (in £).

ITEM.	Years.				
	1921	1922	1923	1924	1925
General	760 152	830 645	1 003 472	1 047 584	955 858
Maintenance of permanent way	4 047 100	4 812 637	6 702 296	5 716 549	5 493 940
Transportation	6 724 211	6 615 513	7 026 319	7 555 219	7 351 739
Maintenance of rolling stock	2 445 401	2 410 454	2 435 101	2 706 208	2 633 010
Traffic	6 673 920	7 016 226	7 538 464	8 108 295	8 037 753
Hotels	31 472	24 228	41 132	38 305	39 564
Hospitals and Sanatoria	138 765	194 503	242 981	247 756	253 387
Subsidy to Employees' Relief Association.	361 561	372 031	389 030	402 111	413 384
Secret service fund.	4 000	4 000	6 000	4 000	4 000
Ships	712 726	701 923	774 807	834 911	794 768
Miscellaneous.	825 321	854 313	638 612	621 861	568 545
Total	22 724 629	23 866 473	26 798 214	27 282 799	26 545 948

is credited with the receipts from all sources of business, *i. e.*, passenger and goods traffic, miscellaneous receipts and bank interest, whilst it is debited with working expenses, cost of maintenance and repair of permanent way and build-

ings, interest charges on public and floating loans, subsidies to private railways and other miscellaneous expenses.

Stores purchases.

During the year 1925 a total of nearly £16 000 000 was expended in the purchase of stores and materials for the Japanese Government Railways, of which the following were the principal items : Rolling stock and equipment, £3 193 935; rails and permanent way material, £1 359 929; bridge materials £490 679; structural steelwork, 316 701; copper and steel wire, £187 816; electrical commodities, £845 779; copper and steel tubes, £102 795; machinery and instruments, £581 257; coal, including shipping charges, £4 254 847; timber, £104 826; sleepers, £649 175; cement, £541 442; mineral oils, £183 875; and clothing materials, £417 680.

Financial results.

The financial results of railway working in the years 1918-1925 and, by way of comparison, in 1909, are shown in table III. Nationalisation was effected in 1909, and it will be observed that since then considerable development has taken place. The operating ratio (percentage of working expenses to gross receipts) has been maintained at a most satisfactory level. In 1909 it was as low as 54 %, and even in 1925, the last year for which figures are available, it was only 55 %, an exceptionally low figure in these days; the all-round percentage of profit to capital was 8.6. An analysis of operating receipts and of working expenditure is given in tables IV and VI, whilst in table V interesting figures are produced to show the average revenue, working expenditure and profit per day and per mile for the years 1923 to 1925.

Steam locomotives and rolling stock of the Japanese Government Railways.

The total number of locomotives in the service of the Japanese Government Railways on 31 March 1926, was 3 907, and of these 77 were electric locomotives. There were 10 302 passenger coaches, providing a total seating capacity of 551 451, and comprising 6 398 bogie and 3 152 four-wheeled vehicles, besides 18 electric motor and 734 trailer coaches. There were also in use 59 607 freight wagons, representing a loading capacity of 774 032 tons, as well as 754 privately-owned wagons. The average loading capacity of the covered goods wagons was 11.7 tons, of the open wagons 12.6 tons, and of the coal hopper wagons 16.2 tons. When the railways were nationalised there were necessarily large numbers of different types of rolling stock, and since then every effort has been exerted to reduce the number of types with a view to the greatest possible standardisation. It is anticipated that the near future will witness the disappearance of the four-wheeled coach from the Japanese Government Railways. From 300 to 400 of them are being scrapped annually and replaced by bogie vehicles, and a thousand have been converted into brake vans for freight trains. All brake vans are equipped with automatic air brakes, and, like the cabooses of the American railways, are provided with cooking stoves and sleeping accommodation for the guards. The older low capacity freight wagons are fast being displaced; already all those of less than 10 tons capacity have been discarded, and an average of 2 000 new standard vehicles are being built annually. De-

tails concerning locomotive and rolling stock built during the years 1923-1925 are given in table I.

Steam locomotives.

A certain limitation is placed on the size and power of locomotives working on the Japanese Government Railways by reason of the comparatively narrow 3-ft. 6-in. gauge. Nevertheless, there are numbers of very useful power units in service, four representative classes of which are the following :

a) Class « 8620 », wheel arrangement 2-6-0, weighing 81.25 tons in running order, for local passenger train service; 670 put into service 1914-1926;

b) Class « 18900 », wheel arrangement 4-6-2, weighing 79.68 tons in running order, for express passenger service; 216 put into service 1919-1926;

c) Class « 9600 », wheel arrangement 2-8-0, weighing 94.85 tons in running order, for general freight train service; 770 having been built 1913-1926;

d) Class « 9900 », wheel arrangement 2-8-2, weighing 127.59 tons in running order, for express freight train service; 145 put into service 1923-1926 (fig. 6).

The leading dimensions of these four classes of locomotives, which have been built entirely by Japanese firms, are shown in table VIII. It may be mentioned that, as Japan is not rich in coal, every possible effort has been made to economise in fuel. For this purpose feed-water heaters are mounted on steam locomotives, considerable use being made of Sumiyama's open-type heaters. Efficent head lights and speed recorders are mounted on the latest locomotives.

Coaching stock.

It is of interest to note that the standard passenger coaches are of the same loading gauge as that prevailing on European railways, although the track is of the 3-ft. 6-in., as against the standard (4-ft. 8 1/2-in.) gauge. The principal dimensions of the standard stock are as follows :

	Feet.	Inches.	Metres.
Length overall (with four-wheel bogies)	55	4	(16.860)
Ditto (with six-wheel bogies).	65	8	(20.016)
Outside width	9	6	(2.900)
Maximum height from rail level	13	1	(3.994)

In construction the wooden bodies are similar to those used in European countries, and are mounted on steel underframes. The latter were originally built up with four 8-inch channels as centre and side sills, but the adoption of automatic centre couplers necessitated a change in the design, and experiments have been made with centre sills of the fish-belly type, with lighter side sills. Recently, however, it has been decided to use steel in the construction of all passenger coaches, and this will enable reversion to a simpler design of centre sill, leaving the vertical load to be carried by the steel side framing. Three classes are provided for, but first class accommodation is now included only in the formation of certain long-distance express trains. The coaches are of clerestory construction and have enclosed platforms and vestibules at each end. The outside sheating is finished in « urusi » (Japanese lacquer), which gives an attractive appearance to the coaches and is stated to be more satisfactory than paint and enamel in withstanding the damp climate of Japan and the excessive rainfall which is experienced in certain seasons of the year. The roof is covered with canvas, saturated with asphaltum, sanded and coated with boiled oil. A number of Garland-type ventilators are arranged in the clerestory, and these have in certain cases replaced torpedo, globe and other types of ventilator. The bogies are of the all-steel type, double coil springs being used for equalisers and elliptical springs set for the bolsters.

Fig. 3. — First class saloon coach.

Fig. 4. — Second class sleeping berths.

Fig. 5. — A compartment in a first class sleeping car.

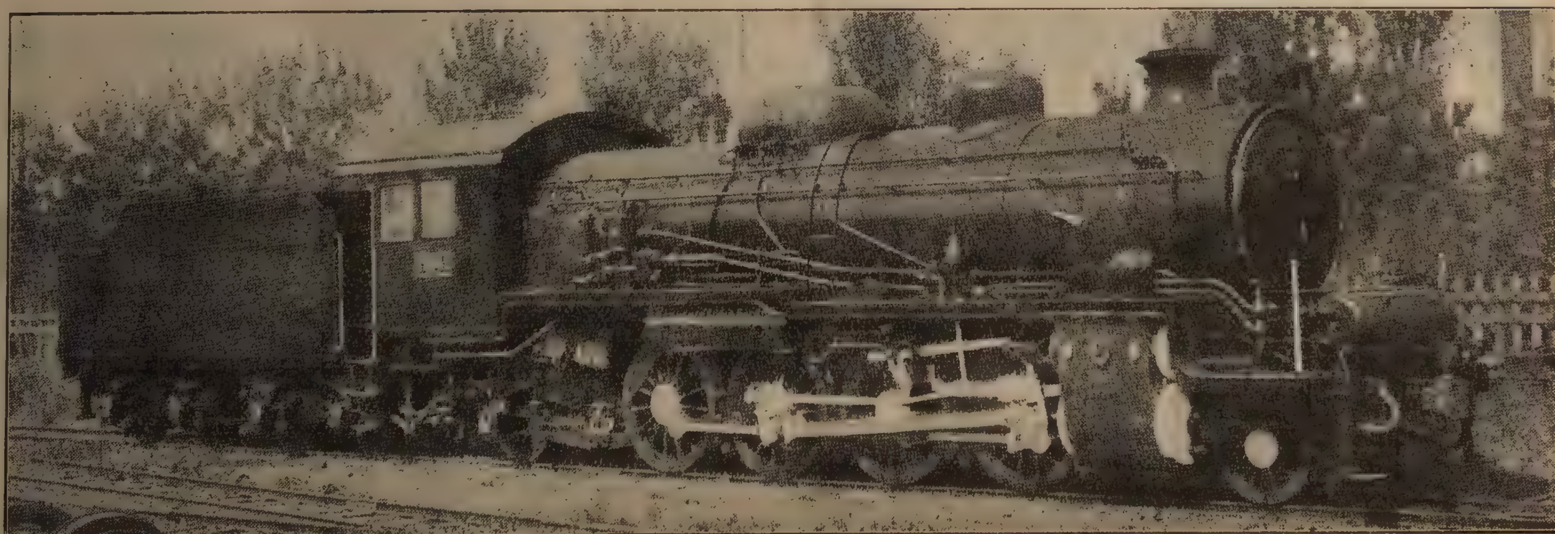

TABLE VII

Locomotives and rolling stock built during the fiscal years 1923-25.

Fiscal year.	Steam locomotives.		Electric locomotives.		Passenger coaches.		Electric coaches.		Freight wagons.	
	Number.	Weight unladen.	Number.	Weight unladen.	Number.	Seating capacity.	Number.	Seating capacity.	Number.	Loading capacity.
		Tons.		Tons.						Tons.
1923	189	12 575.63	21	1 334.50	521	30 052	78	6 840	2 320	37 024
1924	140	9 479.78	15	1 123.50	765	48 539	192	18 660	1 607	26 140
1925	140	11 109.92	12	725.51	582	39 190	105	10 752	2 311	36 910
Average per vehicle . .	...	70.7	...	66.3	...	63	...	97	...	16.0

TABLE VIII.

Leading dimensions of representative types of locomotives, Japanese Government Railways.

	Class « 8620, » 2-6-0 type superheater locomotive for local passenger service.	Class « 18900, » 4-6-2 type superheater locomotive for express passenger service.	Class « 9600, » 2-8-0 type superheater locomotive for general freight service.	Class « 9900, » 2-8-2 type superheater locomotive for fast freight service.
Boiler pressure	185 lb. per sq. in.	185 lb. per sq. in.	185 lb. per sq. in	185 lb. per sq. in.
Cylinders, diameter and stroke .	18.5 × 24 inches.	20.9 × 26 inches.	20 × 24 inches.	22.4 × 26 inches.
Heating surface :				
Tubes.	842 square feet.	1 337 square feet.	1 267 square feet.	1 670 square feet.
Firebox.	109 — —	123 — —	108 — —	145.3 — —
Total	951 — —	1 460 — —	1 375 — —	1 815.3 — —
Superheater area.	297 — —	430 — —	363 — —	670 — —
Grate area.	17.54 — —	27.2 — —	25 — —	35 — —
Distance between tube plates	13 feet.	18 feet.	13 ft. 3 in.	18 feet.
Coal capacity	6 tons.	8 tons.	6 tons.	8 tons.
Water capacity	455 cubic feet.	600 cubic feet.	455 cubic feet.	706 cubic feet.
Length overall.	55 feet.	65 ft. 7 in.	54 ft. 4 in.	65 ft. 7 in.
Width overall	8 ft. 6 in.	8 ft. 10 in.	8 ft. 7 in.	9 ft. 2 in.
Weight on driving wheels. . .	39 tons 15 cwt.	...	52 tons 15 cwt.	58 tons 16 cwt.
Total weight of engine and tender in working order. . .	81 tons 5 cwt.	79 tons 14 cwt.	94 tons 17 cwt.	126 tons 12 cwt.

Interior arrangement.

The seating in the typical second class coach is arranged similarly to that in an American day-coach. It has a central aisle, and the seat backs, which are reversible, are well sprung and upholstered and are covered with mohair plush. The floor is covered with linoleum, cuspidors being conveniently set in the flooring so that they do not stand in the way of passengers passing through the aisle. The ceiling, which is decked with plywood panels, is finished in white enamel to afford reflection of the light. Adjustable ventilator sashes are provided in the clerestories. The windows are of the lift-up type, as on American cars. Drop windows were formerly used, but owing to the abundant rainfall in Japan it has been found advantageous to use lift-up windows in order to prevent rainwater from percolating between the inner and outer waist panels. In the third-class coaches the seats are upholstered, but the backs and armrests are of wood. In the new six-wheeled bogie third class carriages, the backs of the seats are fitted with folding tables in the form of hinged boards, which can be pulled down at will by the passenger. The first class saloon coaches, as used on the « Limited » expresses, are equipped with revolving armchairs, as shown in figure 3.

Sleeping cars

There are two types of sleeping car. One is of the compartment type, having a side corridor similar to European sleeping coaches, and the other is of the open type, with the central aisle common to American Pullman cars. Most of the first class sleeping cars are of the former type, and the second class are in the latter category. Luncheon boxes are sold at every important station, but dining cars are run on all the through trains. There are two kinds of dining car, one providing a European meal, which is becoming increasingly popular amongst the Japanese, and the other being in the nature of a lunch buffet car, in which both Japanese and European meals are served. An observation car is coupled to the rear of every « Limited » express, to enable passengers to obtain a full view of the magnificent scenery through which these trains pass.

It is a matter of interest that as the heating of coaches by steam pressure has been found insufficient in severe weather the vapour system of heating has recently been adopted, and many coaches are being converted to this system. Electricity is employed for carriage lighting, and although there were formerly large numbers of four-wheeled coaches lighted by Pintch gas or oil, these have been re-equipped at the rate of 200 a year, and very few of them remain to be attended to. From the safety point of view, as well as from that of the rising cost of timber, all-steel construction has been on trial for the last two years, and has been adopted in the case of passenger coaches.

Freight wagons.

So rapidly has the renewal of the freight rolling stock been carried out that to-day the majority of the wagons are comprised in but a few standard categories, as follows : 15-ton four-wheeled covered wagon; 15-ton four-wheeled open wagon; 20-ton six-wheeled platform truck; 25-ton four-wheeled bogie flat wagon, and 30-ton four-wheeled bogie coal hopper wagon. For freight traffic a wagon of 17 tons capacity is now under trial. Examples of standard wagons are shown in figures 7 and 8. Recently the couplings on the whole of the rolling stock of the Japanese Government Railways were converted from screw to automatic type, a remarkable achievement, which will shortly be referred to in some detail. Formerly the carriages were equipped with vacuum brakes, and the wagons with only hand or side brakes. But rapid increase in the weight and speed of

Fig. 7. — 30-ton eight-wheeled coal hopper wagon.

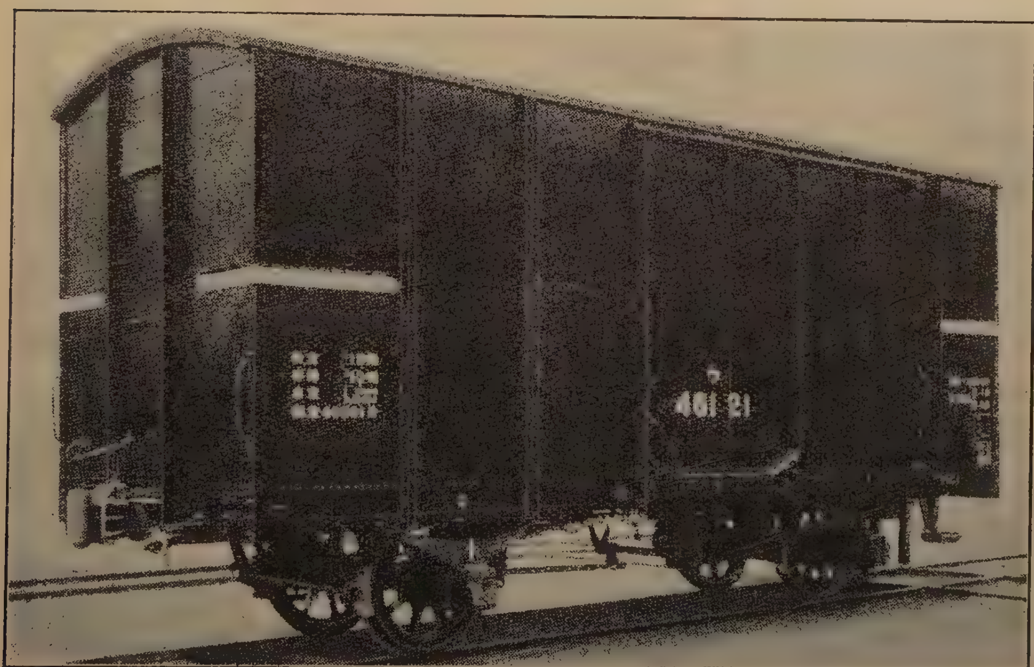

Fig. 8. — Standard 15 ton all steel covered wagon.

trains, especially following the adoption of automatic centre couplers, necessitated more powerful and efficient braking equipment in the form of automatic air brakes. In the course of the last few years two-thirds of the wagons have been fitted with triple valves and brake cylinders, the remainder having brake pipes and couplings only. As some 2 000 newly-built wagons equipped with air cylinders are being put into service every year, the number of wagons having valves and cylinders will rapidly increase in proportion. Both locomotives and rolling stock are being equipped with air brakes in combination with the old system of vacuum brakes, and as soon as the work is completed the vacuum brakes will be dispensed with in favour of the air pressure system. The white horizontal lines which can be seen on the corners of the cars illustrated in figures 7 and 8 indicate that each is equipped with the air cylinder and valve.

Change-over to automatic couplings [1].

Probably the most interesting incident in the history of the Japanese Government Railways occurred in 1925, when there was a complete change-over from the use of hand-operated screw couplings to equipment of the automatic type. It may well be claimed that this revolution was one of the most remarkable achievements in modern railway administration, as the whole of the locomotives and rolling stock were converted on given dates with little or no interference with traffic working. The arrangements had been so carefully prepared and were so efficiently carried out that at a pre-arranged signal 12 000 men, who had been specially trained for the work, and were concentrated at 221 stations, quickly proceeded with their respective duties, and completed them in each case in little more than twelve hours. The rolling stock of the Japanese Railways, except in the Sapporo Region (the island of Hokkaido to the north of the Main Island), had been provided with screw and link couplers, following the practice in European countries, ever since the construction of the first line by an English engineer in 1872. But the necessity of increasing the carrying capacity to cope with the growth of traffic resulting from the development of the railways; the advantage of establishing through car service between the Main Island and Hokkaido, where automatic couplers had been in use for fifteen years; the desire to facilitate the « Safety First » principle owing to the danger of screw couplers in their operation; the need for economy in the saving of working time and expenses; and the insufficiency of strength of screw couplers, which was keenly felt as train loads were increased — these matters led the authorities to realise the urgent necessity of adopting automatic couplers throughout the system. When the volume of traffic, both passenger and goods, increased so tremendously during the war, the substitution of automatic couplers became unavoidable as a means of increasing the carrying capacity of trains. The Ministry of Railways, therefore, decided in 1918 to adopt automatic couplers, and at once began to prepare for the change. Furthermore, it was decided that the couplers of the rolling stock of private railways and private cars should be changed at the same time, in order to provide through services for the whole system, and for this purpose it was agreed to subsidise the work of private railways to half the expenditure for the material and the work.

Preparation for the change.

From 1918 to 1925 preparation was steadily made for the great event by the purchase and the distribution of materials to convenient centres. The prepara-

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[1] See also *Bulletin of the Railway Congress*, August 1926 number, p. 781.

tory work was carried out in three stages. The first stage was the reconstruction of the underframe of the passenger and goods cars by removing the centre sills and attaching to them a pair of follower guides. Wooden centre sills, which were still used in about one-third of the goods cars, not being strong enough for equipment with the automatic coupler, were strenghtened with flat bars and tie rods or angle bars. The central part of the end beam was cut down to make the recess for the coupler, and angle bars were attached to the top and bottom ends of the recess to constitute the upper and lower shank guides. The draw bar, hitherto used, was also arranged with a special washer to receive the draw bar spring. In the case of the locomotive, the pivoted coupler was used, and the pocket bolted to the end beam, while at the rear end of the tender the car coupler was used with the draft gear. The second stage was temporarily to hang the coupler with the draft gear crosswise under the centre sills and to attach the uncoupling of the goods cars. The third stage was to test whether or not the reconstruction work was properly done, so that the change of couplers might be effected without any trouble. The tools and appliances used in the third stage were the same as those used in the actual change. They were devised by many men, and were not uniform throughout. But two essential implements, namely, the jack for the coupler and the spanner for the draw bar nut, were the result of a design competition. The jack was a double-threaded double screw jack. Its minimum height was 400 mm. (15 3/4 inches) so that it could be placed to receive the coupler which was hung under the centre sills of loaded cars, and its maximum height was 827 mm. (2 ft. 8 1/2 in.) so that it might jack up the coupler in its proper position in the case of empty cars. The spanner was specially designed to unscrew the draw bar nut situated just upon the coupler hung under the centre sills. These implements were light, easy to handle, and cheaply made, as they were for temporary use only.

Time-table.

The preparatory work having been successfully accomplished, it was only necessary to train the workmen for the big task, allot the materials to the respective sites, and allocate the work gangs. The general plan for the dates of the coupler changes was decided and carried out as follows. The couplers of the passenger cars which constituted the regular composition of a train, except those at both ends of the train, were changed in the period 1-10 July, during the interval between the arrival and departure of the trains at their terminals. The couplers of spare cars and those laid up at the workshops were changed in the period 11-16 July. On 16 and 17 July advantage was again taken of the intervals between the arrival and departure of trains at the terminals to change the couplers of the locomotives and both ends of the trains. Thus, the passenger service was absolutely unaffected by the work and was run throughout as regularly as usual.

Freight wagons.

It would have been ideal to have changed the couplers of all the freight cars on the same day. But the number of employees available was found to be a little inadequate for such a titanic undertaking, and in view of the fact that even a slight hitch might have caused serious trouble in transportation, it was decided to carry out the work in the Main Island and on the Samiki line in Shikoku on 17 July, and on the Island of Kyushu on 20 July, and thus to secure not only the maximum of success but also the maximum of safety. On these respective days the whole of the freight train service was entirely suspended, except for a few trains carrying fresh fish and other per-

ishable commodities, and all the goods wagons were collected at 221 important stations by midnight of the previous day. It was a difficult matter to allot the predetermined number of cars to a station, but as the result of careful observation for ten days the allotment was a success. The cars were arranged at a regular distance, about 1.2 metres (4 feet) apart, buffer to buffer. This was completed before 5.0 a. m., at which hour the work of changing the couplers commenced. It was anticipated that the work would be finished by 7.0 p. m., but actually, in the Sendai Region it was completed before noon; in the Kobe Region at 4.30; in the Tokyo Region at 5.30; in the Moji Region at 6.30; and in the Nagoya Region at 8.0 p.m.

Organisation.

Altogether 12 506 employees were mobilised for the work, and they were divided into gangs of from three to eight men according to circumstances, the size of gang being left to the discretion of the chief of each workshop. Details of the arrangements are given in table IX. The

TABLE IX.

Number of freight wagons, employees and coupler-changing stations involved in the change-over to automatic couplings.

REGION	Tokyo.	Nagoya.	Kobe	Moji.		Sendai.	Total.
				Sanyo district.	Kyushu district.		
Pre-determined allotment of cars.	15 000	10 000	10 000	2 500	8 650	6 500	2 650
Ditto for July 17 and 20	12 750	8 300	7 849	1 850	7 162	4 800	42 637
Actual number of freight cars of which the couplers were changed on July 17 and 20.	12 523	8 377	7 607	1 842	7 151	4 170	41 670
Employees engaged on July 17 and 20 :							
Workshop employees	3 183	2 135	1 507	452	1 502	1 032	9 812
Car inspectors.	823	274	720	40	300	358	2 694
Total. . .	4 006	2 409	2 224	492	1 802	1 570	12 506
Number of coupler-changing stations.	50	54	39	8	45	25	221

most important part of the work was the inspection after the change of couplers had been effected. For this purpose the workshop foremen had been carefully instructed and served as inspectors as well as foremen of the work. Only ten cars were found to be faulty, and were sent to the workshops. A most satisfactory feature was the absence of any serious injuries to the workmen in carrying out their unaccustomed and difficult task. The total expenditure incurred in the changing of the couplers, including the cost of the new equipment, amounted to approximately £2 500 000. All the plans of the preparatory work were made at the bureau of mechanical engineering of the Ministry of Railways, and the work was executed at the railway workshops. The change-work was planned by a Minister-

ial Home Department Committee presided over by the Vice-Minister. This committee drew up only a general plan, and a detailed plan was submitted to it by a regional committee nominated in each regional office. The regional committee consisted of the chief of the transportation department, acting as president, the chiefs of the machinery and rolling stock section and traffic department (vice-presidents), and several engineers, secretaries, workshop managers and car distribution agents. When their respective plans were submitted, an executive committee was nominated from the Ministerial Home Department Committee, presided over by the chief of the transportation department of the bureau of traffic and operation, to decide the factors common for all regions, and joint meetings were held at which the necessary arrangements were made.

Details of one region.

The organisation of the executive force was not identical throughout all the regions, though it was very similar. As an example, the organisation of the Tokyo Region may be referred to. The headquarters were situated in the regional office. The region was divided into ten districts, each being placed under a chief of a divisional traffic office or a works manager. These districts were subdivided into nineteen local quarters, each under the charge of one of the leading engineers of the workshops. Within the local quarters there were fifty-four acting groups, each under the charge of an assistant-engineer of the workshops. Each acting group was allocated to one of the fifty changing stations, the four greatest stations being allotted two groups each. Each acting group was divided into acting parties under a foreman, and each acting party was sub-divided into acting gangs of five to eight workmen according to circumstances. Within the local quarters there were also fifty settling groups, one in each changing station, each under the station master, their function being to arrange the cars as required by the acting group, to prepare lodgings and meals for the acting group, and to dispose of the discarded equipment. In the settling groups the yardmen and workers other than shopmen were employed. The coordination of the whole system was quite satisfactory, and thus the coupler problem was solved. It is noteworthy that the Japanese Railways in Formosa, Korea, and South Manchuria had adopted automatic couplers at their inauguration, and, as the railways in China also use the same type, the couplers of the railways of the Far East are now standardised, with the exception of those on the Russian railways. It should also be mentioned that Japan has the honour of being the first country to carry into effect the resolution of the International Labour Conference which called upon all the countries in the League of Nations to adopt automatic couplers for the purpose of minimising the casualties among railway employees.

Organisation of the Japanese Railways.

Scope of regional and divisional administration.

The Railways of Japan are governed by a Ministry of Railways which embraces a head office, known as the Home Department, and six local regions divided into sections and offices as shown in the chart. Supreme control is exercised

MINISTRY

12 DISTRICT CONSTRUCTION OFFICES.

6 DISTRICT IMPROVEMENT OFFICES.

DISTRICT ELECTRICAL OFFICE.

TOKYO RAILWAY HOSPITAL.

SIX

REGION HEAD OFFICE ORGANISATION.

Department for General Affairs.	Transportation Section.	Machinery & Rolling Stock Section.	Accounts Section.
Marine Section.	Electrical Section.	Maintenance and Improvement Section.	Traffic Department.

5 RAILWAY HOSPITALS.

6 RAILWAY SCHOOLS.

4 SANATORIA.

67 DRESSING ROOMS.

2 RAILWAY HOTELS.

35 DIVISIONAL TRAFFIC OFFICES.

2 308 stations.	7 power section offices.	3 wireless communication offices.	Information offices.
82 signal houses.	5 power stations.	62 steamboats and launches.	Freight agents' offices.
41 signal stations.	12 transformer sub-stations.	Town ticket offices.	Ferry pier waiting rooms.
53 conductors' quarters.	40 car lighting houses.	Business offices.	Marshalling yards.
117 round houses.	Communication office.		
59 car inspecting offices.			
5 electric car sheds.			

by the Home Department, with headquarters in Tokyo, which is under the immediate direction of the Railway Minister. It exercises control over the whole of the Government railways, and also superintends the private railway companies and the South Manchuria Railway. Its organisation is as follows :

a) Minister's Secretariat, comprising sections under the headings Personal Affairs, Documents and Archives, Legal Affairs, Health and Welfare, Labour, and Railway Research;

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ORGANISATION OF THE HOME DEPARTMENT.

MINISTER'S SECRETARIAT SECTION.	BUREAU OF TRAFFIC AND OPERATION.	BUREAU OF MAINTENANCE & IMPROVEMENT.	BUREAU OF FINANCE AND ACCOUNTS.
Personal affairs section. Documents and archives section. Legal affairs section. Health and welfare section. Labour section. Railway research office.	Department for general affairs. Department for foreign affairs. Passenger traffic department. Freight traffic department. Car distributing department. Transportation department. Marine department.	Maintenance department. Improvement department. Building department.	Accounts section. Stores section. First purchasing section. Second purchasing section. Traffic audit section. Clothing shop. Timber treating plant.
BUREAU OF PRIVATE RAILWAY ADMINISTRATION.	BUREAU OF CONSTRUCTION.	BUREAU OF MECHANICAL ENGINEERING.	
General affairs department. Business affairs department. Technical affairs department.	Planning and surveing department. New line construction department.	Workshop section. Machinery section.	
		BUREAU OF ELECTRICITY.	
		Electrification section. Power section. Communication section.	

36 DIVISIONAL MAINTENANCE OFFICES.	2 ELECTRICAL POWER OFFICES.	21 WORKSHOPS.	3 DETACHED REGION OFFICES.
148 maintenance section offices. 41 communication section offices.	6 electric power section offices. 2 power stations. 11 transformer sub-stations.		

b) Bureau of Private Railway Administration, dealing with the granting of charters to private railways, superintending and subsidising private railways, and superintending the railway business of the South Manchuria Railway Company;

c) Bureau of Traffic and Operation, covering all matters affecting traffic and operation of the Government Railways; communication between Government and private railways and shipping companies; international through traffic and foreign affairs;

d) Bureau of Construction, charged

with the investigation and planning of new lines, and the construction of new lines and buildings;

e) Bureau of Maintenance and Improvement, dealing with the maintenance and control of land, permanent way, and structures. A branch office of this bureau is established at Shimonoseki for the carrying out of the Shimonoseki-Moji submarine tunnel scheme;

f) Bureau of Mechanical Engineering, covering the manufacture, maintenance and improvement of rolling stock, as well as workshop administration. A branch office is established at Osaka for the inspection of rolling stock and accessories, and of machinery ordered from private manufacturers;

g) Bureau of Electricity, covering the installation, maintenance and improvement of electrical equipments, and the generation and distribution of electric power;

h) Bureau of Finance and Accounts;

i) Certain district offices in charge of new works and important electrical undertakings are administered under the immediate control of the Home Department in order to avoid circumlocution. These include twelve district construction offices, six district improvement offices, and the Tokyo district electrical office, which is concerned with electrification in the Tokyo district.

Local regions.

The administration of the Government Railways is decentralised under six local regions, with headquarters at Tokyo, Kobe, Nagoya, Moji, Sendai and Sapporo. Each regional headquarters, subject to the control of the Railway Minister, is responsible for the whole of the working of the lines in its charge, as well as for the carrying out of railway construction and improvement in accordance with the orders of the Railway Minister. The headquarters of each region are divided into departments as shown in the chart. The following are the various branches of management covered by the respective departments and sections of a region head office :

Department for General Affairs : Documents and archives, personnel, health and welfare, and indemnification.

Transportation Section : General, electrical operation, locomotive operation, passenger and freight rolling stock operation.

Machinery and Rolling Stock Section : General and rolling stock.

Accounts Section : Accounts, revenue, stores, purchasing, supply, and audit.

Marine Section : General and operating.

Traffic Department : General, passenger, freight, car distribution, and marine.

Maintenance and Improvement Section : General, maintenance, and improvement.

Electrical Section : General, power, communications, and electrical instruments.

The various railways comprised in each region are in their turn divided into from five to seven divisions, each under the management of divisional traffic and maintenance offices. The divisional traffic office is responsible for all operating matters, including the supervision of rolling stock and electrical equipment, whilst the divisional maintenance office has charge of the maintenance of the permanent way and also of any construction and improvement works allotted to it.

Officials and employees.

The officials in each department are classified into two groups : « Koto-kan » (higher-grade officials) and « Hannin-kan » (lower-grade officials), there being appriximately 913 in the former category and 20 107 in the latter. Thirty-five of-

ficials are permanently occupied abroad in observation and research work. The « Koto-kan » group is sub-divided into two classes. These are known respectively as « Chokunin-kan », the directing class, to which appointments are made by the Emperor and which embraces the Minister, Vice- Ministers, Councillors and Directors, and the «Shonin-kan», a slightly lower grade, appointments to which are at the disposal of the Government with the Emperor's approval. Next to the Railway Minister the most important official in the « Koto-kan » class is the Parliamentary Vice-Minister, who corresponds to an Under-Secretary of State; he is appointed from amongst the members of the Diet and assists the Minister in Parliament and in various political activities. Then come the Permanent Vice-Minister, who corresponds to a Permanent Secretary and is a regular civil servant, and the Parliamentary Councillor, whose duties are similar to those of a parliamentary secretary. Other members of the « Koto-kan » grade include the directors of the various bureaux of the Home Department and of the different regions, the private secretaries to the Minister, secretaries, junior secretaries and engineers. The « Hannin-kan », or lower-grade class, embraces the clerical staff and assistant engineers.

Salaried staff.

The salaried staff is comprised in the two main groups — « Koto-kan » and « Hannin-kan » — above referred to. The officials are permanent civil servants and receive salaries which are fixed by law. They are given according to rank and irrespective of the actual duties performed. In the « Koto-kan » group the Minister receives a salary of £800 and the Vice-Minister one of £650 per annum. The other officials in the superior (« Chokunin-kan ») rank of the « Koto-kan » group are divided into four classes, receiving £600, £550, £520 and £480 per annum respectively. The salaries for grades in the lower (« Shonin-kan ») rank vary, according to class, from £450 downwards to £110 per annum. In so far as the «Hannin-kan», or lower grades are concerned, the officials receive monthly salaries of from £4 in the lowest to £16 in the highest class. The foregoing figures would seem to indicate that the cost of living in Japan is decidedly lower than in this country. For the purpose of comparison it may be stated that, according to the British Income Tax Acts, the personal allowance for an individual whose wife is living with him is £225, while the similar personal allowance under the Japanese Income Tax Law is 1 200 yen, no discrimination being made between the individual living alone and the one living with his wife. From these facts, the following comparison of the cost of living and the purchasing power may be deducted, taking £1 as roughly equal to 10 yen :

a) Cost of living in England, 100.
Cost of living in Japan, 53.

b) £1 in England is equivalent to £1 17sh. 8d. in Japan.

Wages of employees.

The wage-earning employees, who number approximately 180 000, constitute 80 % of the total on the Government railway pay-roll. They are divided into three classes — « Tetsudoshu » (foremen), « Koin » (employees), and « Yonin » (lower employees). Employees of the « Koin » class, who receive £5 or more a month, are usually paid monthly, the other employees receiving their wages daily. Those in the « Yonin » class fall into three groups. The first group are paid daily, irrespective of time on duty; the second group, mostly permanent-way men, are paid overtime at an hourly rate of 10 % of their daily wages for periods of more than two hours (one hour in the case of tunnel working, after their normal period of duty, and extra pay of 3 %

an hour for duty performed before 5 a.m. and after 8 p.m.; whilst the third group, which embraces workshop hands and electric linemen, receive overtime on a very similar scale. Employees other than those in the third group receive wages when off duty on legal holidays and while under treatment for injuries sustained in the execution of their duty. When called up for military or naval training, under the Conscription Act, they are paid the difference between their Army or Navy pay and their railway wages, the latter being usually much higher. A number of extra allowances are given for special services rendered by employees under various circumstances, as, for example, booking clerks engaged in particularly busy offices, staff engaged regularly on night duty, train crews incurring travelling expenses, and employees engaged on particularly dangerous duties, such as coupling and working in tunnels. Slight additional pay is also given to men who have been in the service for five years and upwards, and a bonus is allowed to all employees twice a year in June and December.

MISCELLANEOUS INFORMATION

[621 .156.1 (.42)]

Locomotive tender with side corridor, London and North Eastern Railway.

Figs. 1 to 4, pp. 713 and 714.

(From *The Railway Gazette.*)

The popularity of the non-stop run to Newcastle, which was a feature of the East Coast Anglo-Scottish services last year, made it clear that there is a considerable public demand for improvements of that kind, and the London & North Eastern Railway have for some time been exploring the possibility of extending the distance covered without stopping. It was felt that the limit of the powers of a single engine crew had been reached, and that it was undesirable on grounds of safety to carry two crews on one engine. Some method had, therefore, to be devised by means of which engine crews could be changed *en route*, and the provision of a corridor on the tender supplied the solution to the problem.

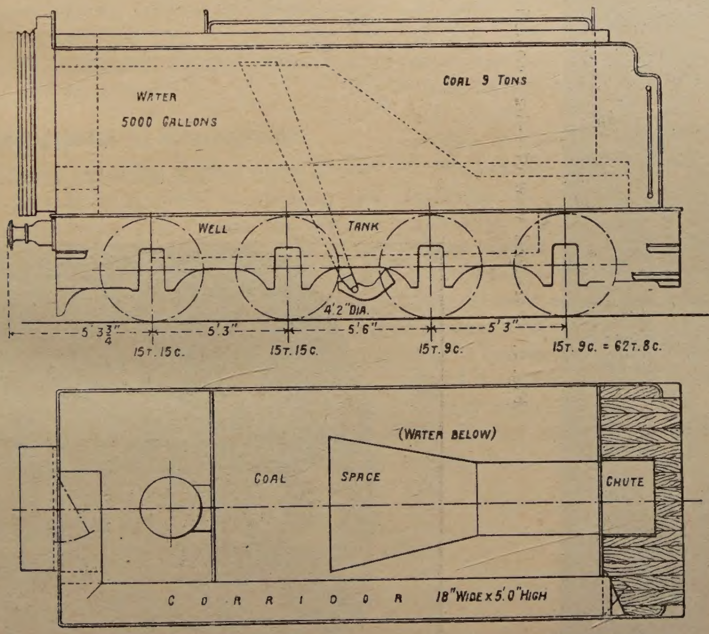

Fig. 1. — Elevation and sketch plan of tender.

This has now been carried into effect, and two of Mr. Gresley's three-cylinder Pacific-type engines, *i. e.*, 4472, *Flying Scotsman* and 4476, *Royal Lancer*, have been fitted with the

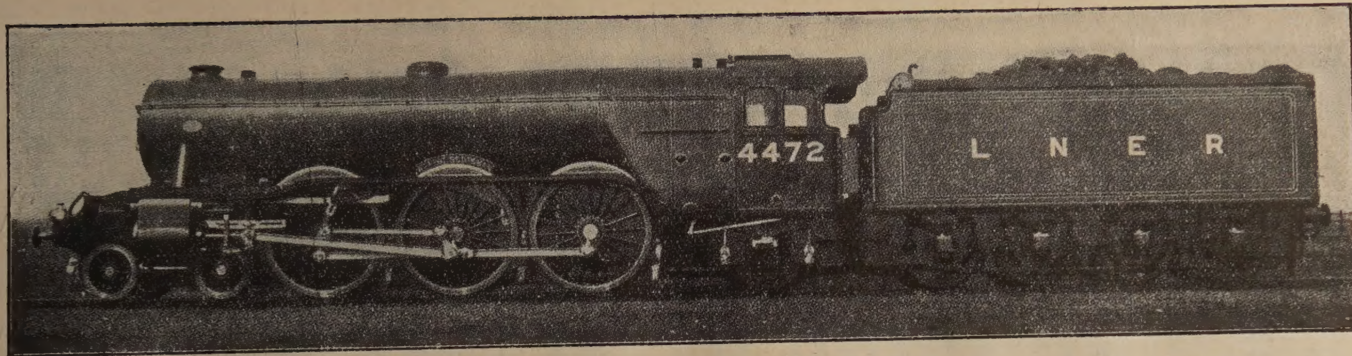

Fig. 2. — General view of 4-6-2 locomotive fitted with new tender.

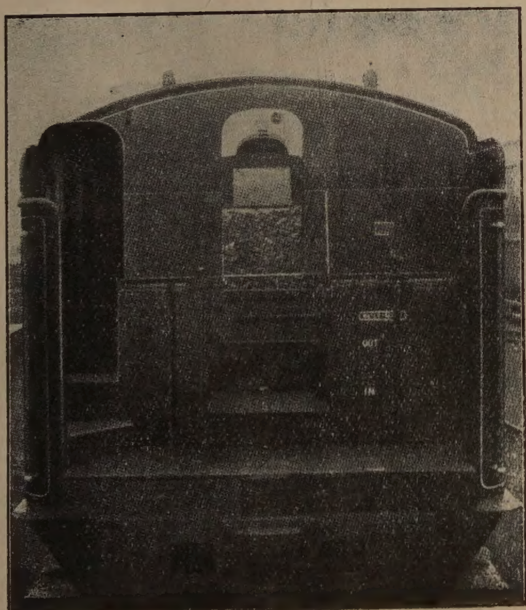

Fig. 3. — Footplate end of tender.

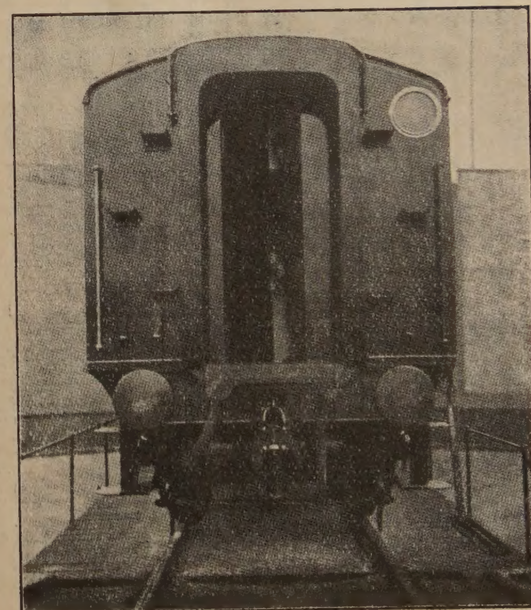

Fig. 4. — Corridor opening at rear of tender.

new tenders. These were employed for inaugurating the new London-Edinburgh non-stop runs commencing on 1 May 1928, and eight other engines of the same class will be similarly equipped. The driver and fireman in charge on leaving London are relieved as the train passes Tollerton, 197 1/2 miles from King's Cross, or roughly, half-way on the journey, the off-duty crew riding in the foremost third-class compartment in the train. On reaching the change-over point the relief crew will pass through the brake van next the engine, and by means of the vestibuled connection with the tender, enter the corridor leading to the footplate, those coming off duty passing back to the train in a similar manner.

The advantages to the travelling public of enjoying an uninterrupted run of 392.7 miles are supplemented by other advantages of a kind which favour the locomotive workings. Fewer engines are required, thus resulting in a corresponding reduction in stand-by losses, while improved engine mileage will be obtained, and by restricting the two crews to the one engine it may be anticipated that better working results will be secured.

Arrangement of side corridor.

The necessity of using a good class of coal on a run of this magnitude is obvious, and a point in this connection is that the engines are equipped with shaking grates. The gangway, or corridor, is located on the right-hand side of the tender looking forward, and entirely covered in. It has a width of 18 inches and a height of 5 feet. Steps at each end of the tender afford access from the level of the gangway or corridor to that of the engine footplate at the front and the vestibule flooring at the rear. Circular windows are provided, one at each end of the corridor, for lighting the interior. The whole arrangement is neat and compact, and there is not the slightest difficulty in passing from the brake van to the footplate, or *vice versa*, even when travelling at high speeds.

The sketch plan (fig. 1) shows approximately the relative dispositions of the water and coal spaces. The tender is self-trimming and 9 tons of coal are carried. The sides are higher than in the original design of tender fitted to these engines, and the guard rails are consequently omitted. The water space is arranged as seen in the sketch plan, and there is, in addition, a well tank holding approximately 250 gallons of water, water pick-up apparatus being fitted.

The tender is of the eight-wheeled pattern with rigid axles, and weighs in working order 62 tons 8 cwt., as compared with 56.5 tons of the original standard tender, the coal capacity of which was, however, 8 tons in place of 9 tons. A door is provided at each end of the corridor on the tender. Measures have been taken to counteract the lack of balance due to the empty space formed by the corridor on the right-hand side of the tender by the provision of extra weight on that side below the corridor.

We had the opportunity of travelling a short distance on the locomotive and in the brake van over a system of lines adjoining King's Cross station, the bulk of the distance being on reverse curves and over junctions, and the arrangement appears to work with the utmost freedom and smoothness.

The new non-stop run, of 392.7 miles between London and Edinburgh, which commenced on 1 May 1928, is the longest in the world, no locomotive engine in regular service having worked such a mileage before without a stop.